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THE DEVELOPMENT AND USE OF DDT FOR THE CONTROL OF MOSQUITOES*

E. F. Knipling

*U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Orlando, Florida***

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Soon after our entry into the war the research program of the Bureau of Entomology and Plant Quarantine, at its Orlando, Florida, laboratory, was expanded to include investigations on the development or improvement of mosquito larvicides. At the request of certain military and civilian authorities research on larvicides was initiated in October 1942. Investigations on the control of adult mosquitoes were started early in 1943 in efforts to develop more effective methods of control and to find substitutes for pyrethrum, supplies of which had become scarce. Tests are being continued under a variety of field conditions with different formulations and by different means of application.

This paper is a resume of some of the results obtained up to the present time. Information contained in this report has been given in more detail in training conferences for personnel of the Army, Navy, and U. S. Public Health Service, as well as of allied nations, during the course of investigations at Orlando.

In investigations on mosquito larvicides one of the principal projects was the testing of new materials for the purpose of finding some that were more effective than the arsenicals and petroleum oils which were in wide usage in mosquito control. Tests against lice in November 1942 with the insecticide DDT (2.2-bis(*p*-chlorophenyl)l, l, l-trichloroethane), discovered by J. R. Giegy a. g., of Switzerland, fully confirmed the claim made by this firm that DDT was a promising insecticide. Brief reports on the value of DDT against human lice, houseflies, bedbugs, and certain other insects

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of medical importance are included in a composite report by Annand *et al.*, (1944). More recently the development of DDT for use by the armed forces has been summarized (Knipling 1945) and studies with lice (Bushland *et al.*, 1945, Jones *et al.*, 1945, and Eddy, unpublished), houseflies (Lindquist *et al.* 1945), and bedbugs (Madden *et al.*, 1945) have been described in greater detail.

Following the promising results with DDT against human lice, tests were made with the insecticide against mosquitoes. The material was immediately recognized as the most toxic larvicide known, and intensive laboratory and field studies soon established that it was not only highly effective but very versatile in its uses as a mosquito larvicide.

Insecticidal Preparations of DDT

DDT is a white chrystalline organic compound with a melting point of 107°-108° C., and a density of about 1.6 grams per milliliter. The technical grade as manufactured at present has a setting point of 88° C. or above. It is prepared commercially by allowing chloral or choral hydrate to react with monochlorobenzene in the presence of sulfuric acid.

The various studies with DDT have necessitated a consideration of many formulations for use in biological tests (Jones *et al.*, 1945). This compound has been found useful in mosquito control when applied in dusts, solutions, emulsions, or suspensions. A number of suitable solvents have been developed and recommended to the armed services, and several emulsifiers have been found satisfactory for use under military conditions.

DDT AS A MOSQUITO LARVICIDE

Laboratory Studies

The laboratory investigations leading to recommendation for the use of DDT as an anopheline larvicide have been described by Deonier *et al.*, 1945. When tested as a colloidal suspension from acetone, DDT proved many times more toxic than previously known larvicides. Table 1 shows the remarkable kills of fourth instars of *Anopheles quadrimaculatus* at various concentrations of DDT in distilled water.

It will be noted that a concentration of 1 part of DDT to 100 million parts of water produced complete mortality in 48 hours. The median lethal concentration for *quadrimaculatus* larvae is indicated to be about 1 part of DDT to 400 million parts of water, and some toxic action is indicated at a concentration as low as 1 part of DDT to 1 billion parts of water. Similar results have been obtained with DDT applied in aqueous emulsions.

Table 1.—Relative toxicity of colloidal suspensions of DDT and phenothiazine to fourth instars of *Anopheles quadrimaculatus*. Average of 5 replications.

Material	Concentration	Average Mortality After 48 Hours
	P.p.m.	*Per Cent*
DDT	0.01	100
	.005	94
	.0025	55
Phenothiazine	1.0	79
	.1	10
	.05	7

Although DDT is inherently toxic to mosquito larvae, studies by Maple (1945) indicate that larvicidal action is caused in part by action on the nervous system so that the larva cannot remain afloat. Its inability to coordinate movements results in suffocation at very low dosages.

In tests to determine the relative effectiveness against *Anopheles quadrimaculatus* of DDT and paris green at various rates of application, DDT was found to be at least 25 times as toxic as paris green, (see table 2).

Table 2.—Relative toxicity of DDT and paris green, applied as a surface application, to fourth instars of *Anopheles quadrimaculatus*. Average of 5 replications.

Material	Rate of Application	Average Mortality After 48 Hours
	Pounds Per Acre	*Per Cent*
DDT	0.01	100
	.005	95
	.0025	87
	.001	62
Paris green	.1	85
	.05	76
	.025	49
	.01	12

Laboratory studies show also that DDT is highly stable when applied to the water surface. In dosages equivalent to 0.1 pound per acre on undisturbed water it remains effective for several weeks.

The larvicide also has nonwetting properties. Using an artificial rain-producing device, Deonier *et al.*, (1945) found that DDT applied as a dust was relatively resistant to loss in effectiveness due

to rains. A number of materials added as coatings for DDT were tested to determine their value in increasing its nonwetting properties. The most promising thus far is stearic acid. A public-service patent has recently been granted to Deonier and Jones (1944) for a composition of matter using DDT and stearic acid.

Although most of the studies with DDT in petroleum-oil solutions have been made in the field, laboratory studies have shown that this material is highly active in oil solutions. In this form its effectiveness per unit of toxicant is about the same as when applied in dust form or as a suspension.

DDT is highly effective not only against anopheline mosquitoes but also against various culicine species (Eide *et al.* 1945). Table 3 shows the toxicity of DDT to fourth instars of *Culex quinquefasciatus* Say and *Aedes aegypti* (L.) when applied to distilled water in various concentrations from a dilute acetone solution.* The relative effectiveness of phenothiazine at 1 p.p.m. is given for comparison.

Table 3.—Toxicity of DDT and phenothiazine to fourth instars of *Culex quinquefasciatus* (average of 6 replications), and *Aedes aegypti* (average of 4 replications).

Material	Concentration	Average Mortality after 48 Hours	
		Culex quinquefasciatus	*Aedes aegypti*
	P.p.m	*Per Cent*	*Per Cent*
DDT	0.05	100	100
	.033		99
	.025	94	95
	.02	88	96
	.013	79	90
	.01	41	86
Phenothiazine	1.0	88	92

Field Studies

In field studies natural breeding places were treated with DDT in various forms, including dusts, oil solutions, aqueous emulsions, and liquefied-gas aerosols, and applied with different types of equipment. These studies are discussed by Deonier *et al.* (1945). Some of the more significant results are given below.

Tests with dusts against *Anopheles quadrimaculatus* and *A. crucians* were conducted in central and northern Florida, using ordinary hand dusting equipment. Dosages as low as 0.1 and 0.05 pound of DDT per acre consistently gave complete or nearly

[2]These tests were conducted by R. Bushland, employing the standard technique used in studying different organic compounds as mosquito larvicides.

complete control. Such low dosages, however, did not show residual effectiveness.

To determine the lasting qualities of various kinds of DDT dusts, approximately 20 tests were made under different conditions with applications at the rate of 1 to 2 pounds per acre. These studies showed that the higher dosages will prevent all but negligible breeding for 4 to 8 weeks, provided the water surface is well protected by a heavy growth of vegetation. In breeding areas having sparse to moderate vegetation cover the residual action is erratic, and breeding may be resumed in some cases 1 week after application, although an apparent retardation was evident in most tests for 1 to 2 weeks.

In areas where the surface film of the water is subject to shifting due to wind, rain, or other causes, heavy dosages may prove wasteful. In order to prevent waste a minimum killing dosage of 0.1 pound of DDT per acre or less has been recommended for routine application.

DDT is also highly effective when dispersed in petroleum oils. The indicated effective dosage is in the same order as for dusts. The oils in most instances serve as excellent spreading agents for the DDT. Various concentrations of DDT in oil solutions have given effective control of *Anopheles quadrimaculatus* and *A. crucians* larvae at dosages as low as 0.05 and 0.025 pound of DDT per acre. One important limiting factor, however, in the use of low dosages is the inability to obtain adequate coverage with ordinary spray equipment now used in oiling operations.

The recommendations for applying DDT in oil solutions for control of anopheline larvae call for the minimum amount of oil that will allow adequate coverage with adjustment of the DDT concentration so that the dosage will be 0.1 pound of DDT per acre. Various types of spray apparatus have been found satisfactory when proper adjustments are made. Other more simple means of applying oil solutions have also given good results.

Several DDT emulsions have been tested under various conditions in the field and have been found equally as effective as oil solutions when applied in the same manner and at equivalent dosages of DDT. The emulsion concentrate can be diluted with water of any type to any desired percentage of DDT and applied as a spray. For routine use a dosage of 0.1 pound of DDT per acre has been recommended. When a fine spray is used, the DDT is generally calculated on the basis of pounds per surface area, since it has a tendency to remain on the surface. However, when dispersed in the water through agitation or when a coarse spray is used, it is generally calculated on a parts-per-million basis.

Field observations indicate that concentrations of DDT below 0.1 p.p.m. in emulsions are not fatal to fish. Since effective control of *Anopheles* larvae can readily be obtained at this or even much lower concentrations, this method of using DDT has been recommended to the armed forces for routine control of larvae. Field tests in Florida indicate that concentrations as high as 1 p.p.m. will prevent *Anopheles* breeding for four weeks or longer when applied in quiet pools. In situations such as shell holes, fox holes, temporary pools, and borrow pits, where fish or other forms of aquatic life are not a factor, higher concentrations may prove desirable.

Emulsions of DDT have a number of advantages over dusts or petroleum-oil solutions: The chief advantages are (1) saving in transportation, (2) ready adaptability to the use of various concentrations for application under different conditions, and (3) possibilities of employing residual dosages under conditions not effective with oil solutions or dust larvicides. The principal disadvantage of the DDT emulsion is the greater toxicity to fish, and possibly other types of aquatic life.

DDT has also been employed in field tests against a number of species of culicine larvae., Eide *et al.*, (1945). The same methods of application were used as against anopheline mosquitoes. Except when DDT was applied as a dust, effective control was obtained. Somewhat higher dosages of DDT appear to be necessary for *Aedes* and *Culex* species than for *Anopheles quadrimaculatus*. DDT in emulsion form is indicated to be more effective than oil solutions of DDT, especially in catch basins, abandoned cisterns, rain barrels, and similar types of breeding areas.

Other Methods of Applying DDT

Various other methods of applying DDT have been considered. It has been found effective when applied as a liquefied-gas aerosol (Jones *et al.*, 1945). Drip cans have been tested as a means of dispensing DDT solutions and may have limited uses in *Anopheles* control. DDT solutions impregnated on sand, sawdust, and other materials may also be used.

The foregoing discussion on the use of DDT larvicides is limited to applications employing ground equipment. The application of DDT from aircraft is mentioned elsewhere in this report.

Use of DDT in the Form of Residual Sprays

The use of spray deposits as a means of controlling certain insects of medical importance, including adult mosquitoes, was given consideration early in the investigations at Orlando. Promising results were indicated for pyrethrum, and the remarkable residual insecticidal properties of DDT were soon observed in studies with bedbugs (Madden *et al.*, 1945) and houseflies (Linquist *et al.*,

1945). Weismann (1943) reported effective control of flies for several weeks after applying DDT sprays to the walls of stables.

Tests were started in April 1943 to explore the possibilities of applying DDT as a residual spray for the control of adult mosquitoes. In early tests in the laboratory treated cages were used. Several dosages of DDT in various kinds of DDT solutions were applied to wood and canvas surfaces (Gahan *et al.*, 1945). Adults of *Anopheles quadrimaculatus* and *Aedes aegypti* were killed when confined in cages treated with DDT applied at rates from 10 to 400 mg. per square foot of surface. Most of the tests were made with 50 mg. of DDT per square foot. The majority of the treatments gave complete control of the mosquitoes as long as 8 months, when they were confined for 24 hours. Tests were discontinued after 8 months, although it was evident that the treatments were gradually losing their effectiveness. DDT is slow in its insecticidal action: several hours of continuous exposure are required to cause 100 per cent knock-down. However, when knocked down, adult mosquitoes rarely recover. Table 4 shows the results on *Anopheles quadrimaculatus* of continuous and short exposure tests with DDT applied in a kerosene solution. Tests with *Aedes aegypti* indicate that this species may be slightly more susceptible to DDT spray deposits than is *Anopheles quadrimaculatus*.

Table 4.— Toxicity of DDT residue to *Anopheles quadrimaculatus* adults exposed in wooden boxes treated with various dosages of DDT. Average of 5 tests, 4 months after application.

Dosage of DDT	Continuous Exposures					Short Exposures				
	Knockdown in—					Mortality 24 Hours after Exposure of—				
	1 Hour	2 Hours	3 Hours	4 Hours	Mortality in 24 Hours	¼ Hour	½ Hour	1 Hour	2 Hours	4 Hours
Mg. per Sq. Ft.	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
50	6	45	70	82	100	29	41	37	61	92
100	7	55	85	94	100	29	42	54	75	89
200	16	64	97	100	100	46	56	77	92	100
400	10	76	96	98	100	36	67	63	85	100

Field tests with residual treatments were started in August 1943 in the vicinity of Tallahassee, Fla., and Stuttgart, Ark. (Gahan *et al.*, 1945). Various types of spray solutions and dosages ranging from 65 to 400 mg. of DDT per square foot were applied to build-

ings harboring adult mosquitoes. These early tests showed promising results, and one treatment remained effective for at least 7 weeks, at which time observations were discontinued because cold weather reduced the mosquito population.

It was observed that mosquitoes exposed to DDT-treated surfaces were activated soon after exposure and attempted to leave the treated building. In order to determine whether the mosquitoes obtained a lethal dose before leaving, one of the buildings near Tallahassee, treated 70 days previously at the rate of 68 mg. per square foot, was chosen for some detailed observations. The windows and doors of a treated room were closed at daybreak, trapping 66 *Anopheles quadrimaculatus* adults that had voluntarily entered. Mosquitoes captured as they came to the closed window in efforts to leave the building showed 95 per cent mortality after 24 hours. Of 135 adults obtained from untreated buildings and released in the treated building, 89 per cent died within 24 hours. All the surviving mosquitoes were females, but over 70 per cent of the females were killed.

Tests on a large scale were initiated at Stuttgart early in 1944 in cooperation with the Arkansas State Board of Health (Gahan *et al.*, 1945). The tests involved treating the inside of all buildings (with the exception of screened houses), bridges, and other readily accessible natural or artificial resting places for *Anopheles quadrimaculatus* in two areas of 9 square miles each. DDT was

Table 5.—Reduction in abundance of *Anopheles quadrimaculatus* adults, and resultant reduction in larval populations, caused by 208-mg. dosages of DDT in buildings, applied May 5-20, 1944, at Stuttgart, Ark.

Observation Date	Reduction of Adults in Buildings	Observation Date	Reduction of Larvae in Rice Fields Nearby[1]
	Per Cent		*Per Cent*
June 20-23	99+	June 20-23	43
29-30	99+	29-30	83
July 14-15	99+	July 7-8	55
29	99+	13-14	85
August 10-11	99+	20-21	89
18	98	27-29	87
25	97	August 2-3	58
September 2	99+	16-17	68
12-13	99+	22-23	41
25	98		
October 17-18	100		

[1]These studies involved a total of 2611 dips in the treated plots and 2370 in the surrounding untreated area.

applied in kerosene or emulsion at a dosage of 208 mg. per square foot of surface in one area and at 56 mg. per square foot in the other. A total of approximately 230 pounds of DDT was used in these large-scale tests. Some of the data obtained in connection with the tests with the 208-mg. dosage are summarized in table 5.

A very high and consistent reduction in the number of mosquitoes in the treated buildings is shown. During the entire season in those buildings routinely checked there were on an average 309 *Anopheles* adults per building in the untreated area as compared with 3 in the treated buildings. The heavy dosage appeared to retain its full toxic action throughout the 5-month period after treatment. Although results are not given, the lower dosage is indicated to be somewhat less effective. On the basis of these tests it is considered that a 200-mg. dosage should be adopted for routine use under military conditions.

Of special interest are the results of larval population studies in rice fields within and outside the treated areas, since it is indicated that the treatment of resting places of adults alone greatly reduced the larval population.

The studies on residual sprays thus far discussed apply to the domestic type of mosquitoes, which spend their daylight hours in sheltered places. Certain species of mosquitoes seldom rest inside buildings. The possibilities of heavy residual treatments of vegetation and debris for the control of mosquitoes living in such situations were considered. Studies were conducted in junglelike areas near Cocoa, Fla., where high populations of *Aedes taeniorhynchus* (Wied.) are present. Oil solutions or emulsions containing DDT were applied at various dosages to the leaves and debris, both on the ground and on the vegetation to a height of 3 feet. Results of typical tests on small plots are given in table 6.

Table 6.—Reduction in *Aedes taeniorhynchus* adults in junglelike area treated with DDT, as compared with numbers in the surrounding untreated area. Cocoa, Fla., 1944.

Time after treatment	Reduction[1]	Time after treatment	Reduction[1]
Days	*Per Cent*	*Days*	*Per Cent*
2	97	20	84
4	96	34	84
7	88	40	67
11	94	47	62
14	75	54	66

[1]Based on number of mosquitoes landing on front of trousers in 1 minute.

It is believed that this method of control may prove effective not only against domestic mosquitoes but also in reducing in certain areas mosquitoes that habitually live or rest on vegetation. The use of residual applications of DDT in buildings or other resting places for mosquitoes may thus prove to be one of the most effective and economical means of controlling malaria or other mosquito-borne diseases thus far developed. By providing continuous insecticidal action against adult mosquitoes residual sprays may kill them before they have fed on subjects or, if they have fed on disease carriers, before they become infective. The results obtained by Thornton (1933-35), Ross (1936), Covell *et al.*, (1938), and Russell and Knipe (1939-40) in controlling malaria by adult mosquito destruction with frequent applications of pyrethrum sprays strongly support this belief.

APPLICATION OF DDT IN AEROSOLS

The use of liquefied gas as a means of applying insecticides, as patented by Goodhue and Sullivan (1943), also of this Bureau, has led to the commercial development of containers and the large-scale use of pyrethrum aerosol "bombs" by the armed forces. This means of applying insecticides has proved highly effective against mosquitoes and is especially useful under military conditions. A study begun at Orlando in January 1943, of the insecticidal effectiveness of DDT when applied as an aerosol soon indicated promise for DDT applied in this manner.

Since DDT is only slightly soluble in Freon-12 (dichlorodifluoromethane), the liquefied gas used in these bombs, a suitable auxiliary solvent was needed to keep DDT in solution. A large number of solvents were tested, some of which proved satisfactory.

Numerous biological tests with aerosols containing DDT in various concentrations indicated that against *Anopheles quadrimaculatus* the median lethal dose for DDT is approximately 20 mg. per 1,000 cubic feet with 1 minute exposure, whereas for pyrethrum it is about 1 mg. (Lindquist *et al.*, 1945). An aerosol containing 5 per cent of DDT approaches in toxicity the standard pyrethrum formula now in use, which contains 0.4 percent of pyrethrins and 8 per cent of sesame oil. Against houseflies, however, this concentration of DDT is many times more effective than the pyrethrum standard. Since for military use it is important to have a material effective against both mosquitoes and flies, the DDT is considered essential for a general purpose aerosol.

Although giving a high mortality of mosquitoes and flies, DDT has poor knockdown properties. Most of the emphasis has therefore been placed on the development of an aerosol containing both DDT and pyrethrum. Numerous tests were conducted to determine the

proper ratio of the two insecticides for most practical results against both flies and mosquitoes. Various auxiliary solvents and activators were also considered in cooperation with L. D. Goodhue and E. R. McGovran of this Bureau. On the basis of these investigations a combination DDT-pyrethrum aerosol formula has been recommended for military uses.

Table 7 shows the effectiveness of one type of DDT-pyrethrum aerosol against mosquitoes and houseflies as compared with the aerosol now in use by the armed forces.

Table 7.— Relative effectiveness against houseflies and anopheline mosquitoes of low dosages of the DDT-pyrethrum aerosol as compared with the standard pryethrum-sesame oil formula.

Aerosol	Tests	*Anopheles quadrimaculatus*			*Musca domestica*		
		Knock-down in—		Kill in—	Knock-down in—		Kill in—
		10 Minutes	2 Hours	24 Hours	10 Minutes	2 Hours	24 Hours
	Number	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*	*Per Cent*
DDT-pyrethrum	18	45	88	76	10	9	61
Pyrethrins 0.4% plus sesame oil 8%	18	30	83	68	9	0	8

It may be noted that the addition of DDT to a pyrethrum aerosol markedly increases its effectiveness against houseflies. The presence of the DDT also results in a more effective aerosol against adult mosquitoes.

At a dosage of 3 grams of total aerosol per 1,000 cubic feet, the amount recommended for use by the armed forces, the DDT-pyrethrum aerosol is completely effective against houseflies and mosquitoes. The standard pyrethrum aerosol, although completely effective against mosquitoes, is unsatisfactory against flies.

Tests by Schroeder *et al.* (1945) show that repeated applications of DDT-pyrethrum aerosols also tend to build up a toxic residue on exposed surfaces.

Although aerosols have been considered primarily for use inside buildings or in other confined spaces, rather extensive studies have been conducted with out-of-door applications. Effective reduction of *Aedes taeniorhynchus* can be obtained by releasing the contents of a 1 pound aerosol bomb on a heavily wooded area of 1 acre or more. The aerosol should be released near the ground and should be applied by taking uniform swaths approximately 20 feet wide.

STUDIES WITH ATOMIZED SPRAYS

In the past research on fly and mosquito sprays has been concerned chiefly with determining the minimum concentration of insecticide that will give the desired degree of control. When low concentrations have been used, this has necessitated the application of a large amount of spray to obtain the required amount of insecticide. Experiments by A. W. Lindquist and H. O. Schroeder (unpublished) have demonstrated that a given amount of DDT is essentially as effective whether applied in a highly concentrated or a weak solution. The same has been found true of pyrethrum. This discovery is highly important from the standpoint of savings in transportation, but the greatest advantage probably lies in the fact that light equipment can be designed to atomize sprays without excessive labor or power. As a result of these findings small, pocket-size sprayers which can be used by the individual have been developed. These are now being produced for experimental purposes, and applications for patents are pending. With a small sprayer filled with the concentrated solution, having a total weight of about 8 ounces, as much space can be treated as with 1 gallon of O.T.I. fly spray applied with an ordinary hand sprayer. The pocket-size sprayer contains the insecticidal equivalent of one aerosol bomb weighing 26 ounces.

Tests with finely atomized sprays have shown that for practical purposes they are as efficient as liquefied gas aerosols (table 8).

The mortality, as may be noted, tends to be somewhat higher for the aerosol, although the differences are not great. From a practical standpoint the sprays have several advantages, including cost, economy in application, and savings in transportation.

Table 8.—Effectiveness against flies and mosquitoes of DDT plus pyrethrum when applied as an atomized spray and as an aerosol.

Dosage DDT-Pyrethrins		Method of Application	Mortality in 24 Hours	
			Anopheles quadrimaculatus	*Musca domestica*
1,000 cu. ft.	Mg. per		Per Cent	Per Cent
2	20	Aerosol	83	64
		Atomized spray	73	60
4	40	Aerosol	94	86
		Atomized spray	90	89

THE USE OF AIRCRAFT IN APPLYING MOSQUITO INSECTICIDES

The application of larvicides by means of aircraft has been carried out on an extensive scale for a number of years by the Tennessee Valley Authority and other mosquito-control agencies. The larvicides were restricted to arsenicals, because oils and other materials were not sufficiently effective at practical dosages. The high degree of effectiveness of DDT against both larvae and adult mosquitoes indicated the practicability of applying it from airplanes. Investigations relating to equipment as well as biological tests were therefore undertaken at Orlando, and several new devices have been designed and constructed by C. N. Husman, O. M. Longcoy and H. S. Hensley of this laboratory.

When applied from a hopper installed in a plane, DDT dusts were highly effective, but it was difficult to control the rate of delivery of the dusts containing high concentrations of DDT. Similar observations were reported by the Tennessee Valley Authority. Dusts containing low percentages of DDT were found suitable for application, and a number of successful tests with such dusts were run in Florida and Arkansas.

Thus far most of the efforts in airplane applications of DDT have been concentrated on sprays. From a military standpoint, at least, DDT sprays have a number of advantages over dusts. A spray unit has been designed which has proved very effective as a means of applying larvicides. Favorable results have been obtained also against adult salt marsh and other mosquitoes that remain in vegetation, including *Anopheles albimanus* (Wied.) in Panama.

A dosage as low as 0.2 pound of DDT per acre has given excellent results as an anopheline larvicide. Against adults of salt marsh mosquitoes and *Anopheles albimanus* higher dosages are indicated for use in areas with dense growth of vegetation. Small-plot tests with the spray equipment against adult *Anopheles quadrimaculatus* have not proved effective. DDT in petroleum oil solutions and in emulsions appears to be equally effective against larvae and adults.

A number of other spray units were constructed by engineers at the Army Air Forces Tactical Center (AAFTAC), Orlando, Fla., for the Offices of the Surgeons General of the Army and Navy. These units were sent overseas for testing, and all reports thus far have been favorable. DDT sprays applied from aircraft are now being employed overseas for the control of both larvae and adult mosquitoes.

Various other methods of applying DDT from aircraft have been investigated, including the use of coarse sprays, smokes, and liquefied-gas aerosols. These studies were conducted in cooperation with AAFTAC, the Health and Safety Department of the Tennessee Valley Authority, and Division 10 of the National Defense Research Committee, as well as with other agencies, and promising results against both larvae and adult mosquitoes are indicated.

This is the first time in the history of medical entomology that adult mosquitoes have been controlled over large areas by the application of insecticides by means of aircraft. Such a method of control for malaria and other mosquito-borne disease is especially useful in connection with military operations.

SUMMARY

The results of various phases of investigations with DDT for the control of mosquito larvae and adults obtained at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine are discussed.

The importance of this synthetic organic compound in mosquito-control operations is indicated to be far reaching. The insecticide posseses the unusual properties of high toxicity and stability. The fact that it is effective against larvae as well as adults and against both anopheline and culicine mosquitoes makes it very useful as an all-purpose insecticide for mosquito control. The material has the added advantage of being highly effective against other insects of medical importance. It is readily adaptable for use in a number of ways against a number of species of insects.

DDT has been found effective as a mosquito larvicide at very low dosages when applied in the form of dusts, oil solutions, emulsions, and suspensions.

When used in dust form, DDT is at least 25 times as toxic as paris green to larvae of *Anopheles quadrimaculatus*. Sprays, however, are indicated to be the most desirable method of applying DDT under most conditions. Although the low dosage of approximately 0.1 pound per acre is recommended for routine treatments, higher dosages up to 1 pound per acre can be used for long-lasting treatments under certain conditions.

In the control of adult mosquitoes DDT is shown to be effective in liquefied-gas aerosols, especially when combined with pyrethrum, and its use in atomized sprays offers exceptional promise. There is reason to believe that the greatest promise for DDT in malaria control is through its use as a residual spray. Such sprays are effective for several months in killing adult mosquitoes that are exposed to treated surfaces.

DDT sprays applied from aircraft with recently developed equipment have proved very effective both as larvicides and against adult mosquitoes, and this method is already in use for the control of malaria and other mosquito-borne diseases in connection with military operations.

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Throughout these investigations the staff at the Orlando laboratory has had the cooperation and guidance of W. E. Dove, in charge of the Division of Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, and of H. H. Stage, assistant Division leader. Other workers in this Bureau, as well as members of the Army and Navy, the Office of Scientific Research and Development, the Arkansas State Board of Health, the Health and Safety Department of the Tennessee Valley Authority, the Food and Drug Administration, the U. S. Public Health Service, and Division 10 of the National Defense Research Committee, and a number of other agencies and individuals have also cooperated in this work. The Orlando laboratory has profited also by information on DDT obtained from British investigators, in return for information on early investigations at this laboratory made available to them.

The J. R. Geigy Company, of New York, made available a large portion of their limited supplies of DDT during the early stage of the development of this insecticide.

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CONSTRUCTION AND OPERATION OF A 4-INCH HYDRAULIC DREDGE FOR MALARIA CONTROL DRAINAGE*

LOUVA G. LENERT and WILLIAM A. LEGWEN

State Department of Health, Atlanta, Georgia

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The MCWA operations in Georgia have demonstrated the feasibility of operating small, floating, hydraulic dredging equipment for maintenance or reconstruction work in existing drainage ways.

Southeast of the City of Macon, west of the Ocmulgee River, lies what is known as Stratton Swamp, separated from the river by a low bridge on which run the main line of the Southern Railroad and a dummy line operated by a brick company. The outfall from the swamp runs south parallel to the river and normally discharges into Rocky Creek, thence to the river. During periods of unusual run-off the swamp is subject to overflow, from the creek, the river, the City of Macon, or any combination of these.

During the first year of MCWA operations (1942) a biological investigation of Stratton Swamp indicated that no intensive malaria mosquito breeding was probable, but suitable adult catching stations were established as a screen for the protected industry. These stations reflected no unusual or alarming amount of breeding originating in the swamp during that season.

In 1943 adult mosquito collections showed an alarming increase. Subsequent larval investigations revealed extensive breeding throughout the swamp. The problem of control was exceedingly difficult. Neither the inspection nor the larvicidal measures taken were considered adequate. The extent of the area and the alluvial soil covering the swamp made access impossible to many cases. Quite frequently members of the crews would step into water 12 inches deep and find themselves waist deep in mud.

Stratton Canal was originally constructed through the heart of the swamp to carry off part of the storm water flow originating in the City of Macon as well as to drain the swamp. The canal was never definitely connected to Rocky Creek for reasons not particularly pertinent to this discussion.

When intensive control measures were indicated it was found that many sections of Stratton Canal were completely blocked. Its true location in some sections could be determined only by soundings in what appeared to be the original right-of-way. Depths

*This paper was presented at a meeting of the joint session of the National Malaria Society and the Sanitary Engineers and Sanitation Officers Section, Southern Branch, American Public Health Association, St. Louis, Missouri, 14 November 1944.

ranged from zero to four feet. Obstructions included trestle timbers, piling, large and small limbs and trunks of trees, oil drums, etc., all of which served to assist the deposition of silt and other debris.

Clearing and snagging operations were begun immediately, most of the solid debris being moved manually. A crude drag constructed of two 15 inch square trestle timbers spiked together was pulled through some of the filled sections of the canal thus creating a narrow shallow channel. It is interesting to note that although the silt and sediment accumulated in the canal was not stable enough to support a person, it was sufficiently stable to resist scour or erosion.

Conclusions reached were that dynamite excavation was indicated. This was attempted over a distance of 4,000 feet, the dynamite being placed at depths ranging from 0.1 ft. to 4 feet in the mud. All shots were uniformly poor, the material being temporarily reduced to a semi-suspended state, but measurements indicated removal of only 0.1 to 0.2 cubic yard of material for each pound of dynamite used.

Consultation with a dynamite manufacturer's representative suggested some changes in loading. These recommendations were followed, with no improvement. Subsequently a field representative of the manufacturer visited the site and test shots were made under his direction. There was no improvement in yield and it was concluded that other means of excavation should be attempted.

In passing, it might be mentioned that the combined efforts of snagging, stream clearing, dragging and dynamiting had resulted in reducing the flooded area so that effective though expensive larvicidal operations could be performed.

Dragline equipment could have been used for reconstruction, but this would have required heavy right-of-way clearing and heavy matting to support the equipment. Other unfavorable factors were the high initial cost of the equipment, either on contract or purchase basis, and the probability of the entire area being flooded at times to a depth of 5 to 8 feet.

Floating hydraulic dredging equipment seemed to offer definite possibilities and if at all successful on this canal it could undoubtedly be used on other major malaria control drainageways in the state.

Sand pumping equipment installations were inspected and it was decided to utilize a 4-inch sand pump V-belt connected to a 25 H.P. power unit, as this equipment was available and suited the needs of the project. This combination had a theoretical capacity of 14 cubic yards per hour based upon 10 per cent solids and a flow velocity of 12 feet per second. At Augusta, Georgia a barge 8 feet x 16 feet was constructed using 18 55-gallon used oil drums

for flotation, Four 6 inch x 6 inch stringers and 2 inch x 8 inch decking, the drums being fastened to the stringers with U-shaped ¼ inch iron rods. The 1,000 pound sand pump and 850 pound power unit were located as far back on the barge as possible, their pulleys aligned and the lateral position shifted until the barge deck was literally level. They were then bolted to the 2 inch decking, using ¾ inch bolts. The intake as originally constructed consisted of a 9-foot section of 4 inch suction hose coupled to a "T," the upper side of which was screw-plugged for access for cleaning, and the lower side was coupled to the suction head. This head consisted of a 4 inch nipple, a 4 inch flap valve (to aid in priming) and a 4 inch nipple, the overall suction head being approximately 5 feet. An "A" frame constructed of 3 inch pipe with a 12-foot boom was erected over the sand pump, and a 2-ton winch was bolted to the A frame so that it could power the lifting line of the boom. This 5/16 inch line was attached to the horizontal leg of the suction "T" and carried the weight of the suction line and head, allowing both horizontal and vertical movement of the head in the pumping well. This well was simply a 4 feet x 8 feet opening made by nailing 3 inch x 8 inch timbers to the forward outside stringers and connecting them with a 3 inch x 12 inch board which served as a catwalk for the laborer who worked near the suction head. Two 55-gallon drums were lashed to the underside of this catwalk and provided additional flotation for the forward end of the dredge which then had an overall length of 21.5 feet and a maximum width of 8.5 feet. Subsequently the drums were taken out and the same results obtained by loading the opposite end with two sand bags. The discharge line was made up of two 20-foot sections of 4 inch flexible hose connected with companion flanges. A 1½ inch water pump was installed and connected to the sand pump with quick opening valves so that it could serve as an aid in priming, and for jetting purposes as well as providing back pressure on the packing of the said pump.

The superintendent of the Georgia Sand and Gravel Company was employed on a part time basis to supervise the construction of the dredge and its first weeks of operations.

The costs of the major elements of the dredge were as follows:

4 inch Sand Pump	$247.50
25 H.P. Power Unit	390.00
V Belts and Pulley System	92.88
4 inch Hoses, Suction and Discharge	73.00
Lumber and Hardware	30.77
A Frame and Boom	37.50
4 inch Flap Valve	40.00
	$911.65

The 1½ inch pump was available from other MCWA operations as were the used oil drums and winch which had been salvaged at a cost of $5.00. Assuming a fair market price for the 1½ inch pump, 20 used oil drums, the used 2-ton winch and the miscellaneous fittings, the costs of the materials and equipment for the dredge totaled approximately $1,050-$1,100.

The dredge began operation in Phinizy Canal at Augusta, Georgia, and considerable difficulty was experienced due to the large amount of trash and debris encountered during dredging. A basket type strainer approximately 8 inches x 8 inches x 2 inches, with 2 inch openings, was constructed of ¼ inch rods and it served to prevent most of the line stoppages, but required cleaning at intervals ranging from 2 to 10 minutes.

Backwater from the Savannah River and its tributaries flooded the operations site and it was decided to suspend operations there and move the dredge to Macon to begin operations in Stratton Canal. The pump, power unit and all other above deck equipment was removed from the barge and loaded on a 1½ ton truck. The barge was then loaded intact in an inverted position on a second 1½ ton truck. On arrival at Stratton Canal the dredge was reassembled and put into operation within three hours.

The three men in the Augusta crew were transferred to the Macon area for five days so that they could instruct the Macon crew in their duties. Dredging operations soon revealed that the sediment in the Stratton Canal contained a large amount of debris that continued to clog the strainer. Removal of the strainer resulted in fewer but more serious stoppages in the pump or the suction lines, necessitating their separation and cleaning. The strainer stopped much material that would pass the pump, if admitted in reasonable quantities.

Early in June, an experienced supervisor was assigned to the dredge so that a time study and analysis of operations could be secured. This analysis revealed that the main losses in operating time occurred in cleaning the strainer or lines, repriming the pump and moving the discharge hose. In order to minimize losses of the first two types, the suction head was changed in the following respects: The basket type strainer was replaced by a stirrup type strainer made of ⅝ inch rod which was welded to the 4 inch intake nipple; the 4 inch flap valve was replaced by a locally fabricated gate valve and the screw plug in the suction "T" was replaced by a machined cover attached to the "T" by means of 2 eye bolts, with wing nuts for quick removal and replacement; and a ¼ inch valve was welded into the cover of the "T." The stirrup projecting only 2 inches beyond the intake prevented the entrance of debris of

greater diameter than 2 inch but did permit the entrance of leaves and other similar material which could pass the pump. It also permitted the entrance of long small diameter limbs which were generally stopped at the "T." Access and removal of these were obtained by unbolting the cover of the "T" which was quickly removed and after cleaning, replaced. Priming time was greatly reduced by the use of the ¼ inch valve. The 4 inch gate valve would be manually closed, the ¼ inch valve left open until water flowed through it, indicating the complete removal of air from the suction line, and pumping operations were resumed by opening the gate valve and applying power to the pump by engaging the clutch and pulley system.

Gross and unit costs of the last three months' dredging operations on Stratton Canal are shown in the tabular summary of dredging operations based on the following data:

Depreciation and repairs—Amortization of $1,100 in three years or rate of $0.19 per operating hour; Labor, including foreman, $0.66/man-hour; Lubrication, 1 pint oil or $0.10/machine-hour; Fuel, 2 gallons diesel oil and ¼ gallon gasoline per hour, cost $0.26/machine-hour. All yardage computations based on before and after cross-sections made at 25 ft. intervals.

TABULAR SUMMARY OF DREDGING OPERATIONS

Items	May	June	July	3 Months
Excavation in cubic yards	876	1067	488	2431
Machine-hours required	375	235	74	684
Man-hours required	1408	898	287	2593
Total Costs	$1135.91	$722.17	$230.19	$2088.27
Machine-hours per cubic yard	0.43	0.22	0.15	0.28
Man-hours per cubic yard	1.61	0.84	0.59	1.07
Cubic yards per machine-hour	2.34	4.54	6.59	3.55
Cubic yards per man-hour	0.62	1.19	1.70	0.94
Cost per cubic yard	$1.30	$0.68	$0.47	$0.86

As will be noted from the table, cost per yard of excavation averaged $0.86 for May, June and July, with the minimum cost of $0.47 occurring during July after the suction head modifications were completed.

The Georgia Highway Department, Macon Division Office, furnished the following cubic yard cost data, taken from 1944 contracts; Common and borrow excavation $0.27 to $0.44 in quantities ranging from 100,000 to 250,000 cu. yds., with channel or wet excavation costing from $1.00 to $3.00, depending on size of contract and individual job site conditions.

Factors tending to increase unit costs on the described dredging operations are: labor rates of $0.60 per hour (approximately 25 per cent to 50 per cent above contractor's rate), comparatively shallow depth and narrow width of excavation necessitate frequent movement of dredge and discharge line, trashy type of material to be excavated reduces discharge rate and necessitates frequent cleaning of suction head and line, and occasional cleaning of discharge line.

Dredging operations in Stratton Canal were completed in July, and in October dredging commenced on Swift Creek near Camp Wheeler, Georgia. Conditions there are more favorable in that excavation will be of greater width and depth and the sandy material does not contain as much debris or clogging materials. Preliminary operations there indicate that an average of 15 to 20 cubic yards per machine hour can be dredged, and a maximum discharge rate of 66 cubic yards per hour has been measured. With the 15 cubic yard per hour average, the unit cost would approximate $0.21/cu. yd. excavated.

SUMMARY AND CONCLUSIONS

1. A portable 4 inch floating hydraulic dredge has been construed and operated in reconstructing or cleaning an existing drainageway in a situation where dynamite excavation was not satisfactory or practicable and where dragline or clam shall machine costs were prohibitive.

2. Unit cost data compare favorably with those obtainable under present contractor's unit costs.

3. Dredging operations completed will greatly reduce costly larviciding operations, two years of which would amortize the entire cost of dredging operations.

REPORT ON USE OF A DIAPHRAGM PUMP AND TIDE GATES ON MALARIA CONTROL PROJECT AT HARVEY POINT, N. C.

ROBERT W. JONES, III*
Dispensary, Naval Air Station, Norfolk 11, Virginia

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Harvey Point is a peninsula extending southwestward into Albemarle Sound. The Perquimans River extends along the nothern side of the Point and joins Albemarle Sound at the eastern tip of the Point. The station is located at the end of the Point and is comprised of approximately 1,250 acres of land. The working area of the base is located near the center of this territory and is almost entirely surrounded by cypress swampland. There are approximately three hundred acres of swamp, all breeding *Anopheles quadrimaculatus,* within a one mile radius of the living and working areas. These swamps receive the drainage from the high, and relatively dry, central section of the Point and have no natural outlet into either the Sound or the River.

Along the southern and western boundary of the station extends a heavily wooded cypress and gum swamp. This swamp is approximately two and one-half miles in length and varies in width from six hundred to fifteen hundred feet. There are about one hundred and fifty acres of land in this area.

Work was begun here because of the size of the swamp and its proximity to the barracks area. Dynamite was selected as the means of ditching because of the nature of the swamp; i.e., its wetness and muckiness and the dense growth of cypress and gum trees. The best contour maps available showed the lowest levels of the swamp to be between zero and two feet above the normal Sound level. However, between 75 and 100 acres of this swamp were found to be between a half to a foot and a half below the normal summer Sound level.

A detailed topographical survey was impractical, so an experimental outlet ditch was blown into the swamp. Between the Sound and the swamp proper was a ridge of high ground about two hundred feet wide. When the ditch was blown, the Sound flooded into the low portions of the swamp and it was found impossible even to confine this water to the ditches. The high water table, e.g., one foot below the surface of the ground, and the low levels of the swamp plus the huge surface run-off of storm water had already forced the conclusion that it would be impossible to drain the swamp to a state of dryness. It would only be possible to confine the water to the ditching system so that it would be readily accessible and, therefore, easily oiled during the breeding season.

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*Lieut. (jg), H-V(S), USNR

When this flooding occurred some alternative procedure was indicated. Finally, it was decided to build a cofferdam across the outlet of the ditch and use a pump in order to eliminate the water ponded in the swamp behind the dam. For this purpose, a double-diaphragm gasoline-powered pump was chosen. It was selected because of its extremely simple mechanical operation and its ability to operate in debris-ridden water. Small sticks and trash which would demolish a centrifugal pump exert no influence on the operation of the diaphragm pump. And in this case, the smaller size and increased mobility of the centrifugal pump is of no advantage.

A small but durable and weather-proof lean-to was constructed on the bank of the ditch to house the pump. A concrete floor was installed with bolts set in it at proper intervals to which the pump could be anchored in order to eliminate as much vibration as possible. An extension of the exhaust was carried through the wall of the shack in order to obviate any possibility of the accumulation of carbon monoxide gas within the shack itself. The intake, a four-inch, flexible, wire-reinforced rubber hose, was brought through the wall on the ditch side and the outfall, a length of similar hose, was carried through the opposite wall and so into the Sound.

The pump was obtained second-hand from the contractor at work on the base and has given excellent service. In our hands it has run for a total of 1265 hours in nine months with no visible signs of wear. The rubber diaphgrams have been replaced three times in this nine month period. The pump has a capacity of ten thousand gallons per hour and is powered by a one-cylinder, air-cooled gasoline engine. The gasoline tank on the pump had a capacity of one and one-half gallons of fuel and would run the pump for a period of four and one-half hours. This was insufficient to operate the pump overnight, so a five gallon tank was substituted. This increased the range of operation to fifteen hours, thus eliminating the need of night servicing of the equipment, which means that a twenty-four hour pumping day may be maintained in case the need should arise.

The ditching system is composed of a center-line ditch seven feet wide and three feet deep made by using one stick charge in holes fourteen inches apart and twelve inches deep. Then a contour ditch was blown on either side of the swamp. These ditches average four feet in width and two and a half to three feet in depth. They were blown using a half stick of dynamite in holes twelve inches deep and five inches apart.

The dynamite used was a 50 per cent straight nitroglycerine, a so-called ditching dynamite. The propagation method of firing was used with great success. In this method the individual charges are placed close enough so that by capping one stick, the entire length of charges can be exploded by the concussion from the explosion of the one stick. This method may be utilized in wet soil only as the concussion wave will not propagate in dry, compact soil. Total charges of four cases, or two hundred pounds of dynamite, were used when far enough away from the inhabited areas of the station. As the work progressed and we neared the hangar and barracks area, the charges were diminished until at a distance of a quarter mile there were only twenty-five pounds. This diminution was necessitated because of the undue vibratory effects felt especially in the hangars. These hangars are constructed on piling in a sandy substratum. Some settling was, therefore, to be expected, but apparently the vibratory waves created by the dynamite blasts were carried undiminished by the sandy substratum until they broke on the pilings. This caused more rapid settling than was to be expected normally, so that the charges had to be progressively diminished as the work neared these occupied areas.

The soil in which we worked was a humus, mucky in the extreme. The floor of the swamp was covered with water to an average depth of two feet. In places this depth, (including the soft, slimy muck), was extended to four or more feet. Water remained in the swamp the year round, collecting and ponding up during the winter rains, and evaporating slowly during the summer months. The rains on this part of the coast are frequent enough during the summer so that the water never averaged less than eight to ten inches throughout the swamp, although the uneven floor, covered with stumps and fallen logs, caused individual ponds to appear during this stage.

The water contained a heavy algal growth and was shaded by the dense stand of cypress and gum trees. There was much emergent vegetation, including the various types of water growths indigenous to this section. For these reasons, it was impossible to control breeding by either oiling or the use of Paris green dust; the emergent vegetation would have broken the oil film even if the area could have been covered, while the undergrowth was too dense to allow satisfactory coverage by hand-dusters and the trees too dense to allow satisfactory dusting by planes.

The area was ideal as a *quadrimaculatus* breeding place and close enough so that the barracks area was filled with adult female *quadrimaculatus*. The other swamps were contributing their share of *quadrimaculatus*, but this South Swamp was the chief source, if only because of its size. There are the usual pest types breeding

here as well; viz., *Aedes vexans, A. sollicitans, Psorophora ferox, P. columbiae,* and *Theobaldia melanura.* These are the woods mosquitoes and were seldom encountered in the barracks area, although they were abundant in the swamps.

In blasting the ditches through this type of soil, an average of one and a half cubic yards of earth were moved per pound of dynamite. In addition to this, twenty pounds of dynamite were needed per hundred feet of ditch for the removal of stumps and logs, all obstructions in the course of the ditch. In several places in the center-line ditch, the mud was so soft and fluid that difficulty was encountered in maintaining an open ditch which diminished the flow of water. The contour ditches helped here as laterals were led to them around the soft areas and in this way carried the flow of water.

After the pump was placed in operation and the swamp cleared, it began to dry out and these fluid areas dried and hardened until the cross-section of the ditch could be maintained. The swamp dried rapidly due to a combination of factors; e.g., the exposure of the swamp to both sun and wind because of the clearing of the undergrowth and the thinning of the trees, the exclusion from the swamp of the Sound water by the dam, and the elimination of the ponded rain water by the pump.

During the summer months, the water level of the Sound is high and averages eighteen inches to two feet above the water level maintained in the ditching system. This is the period of least rainfall so that the capacity of the 10,000 gallon per hour pump is not strained. There is no true tidal action in Albemarle Sound at this point, but wind tides of as much as three feet are experienced. The prevailing summer wind is from the south and southeast, thus causing the high summer level of the Sound. However, in the winter the prevailing wind is from the north or northwest, thus causing the water level of the Sound at Harvey Point to average a level one foot below that of the low point in the swamp.

The heavy winter rains come with such intensity and frequency that it is impossible to handle the resultant volume of water by a pump. But, with the low wind tides of this season, it is feasible to open the ditching system and allow the water to flow out. Some means of opening and closing the ditching system at will is thus necessary and a modified, i.e., manually controlled, tide gate was installed.

Before this installation, the contour ditches on either side of the swamp were opened into the Sound to remove the recent collection of fall rainwater. The one on the south side of the swamp was opened first and remained open for a week before the second

was opened. An estimated 144,765,000 gallons of water flowed through this ditch in the week preceding the opening of the second contour ditch. These outlets were five feet wide and flowed two feet deep.

A tide gate was installed at the outlet of both contour ditches and a third was opened into the Sound at another point to act as a safety valve in case the first two failed to empty the swamp fast enough during and after a heavy rain. As a result the ditching system could now be opened and closed to the Sound at will.

The tide gates as installed were of simple construction. The design is one which has been used by the Bureau of Fisheries on their hatchery ponds. Several designs were considered and discarded before this one was finally decided upon as being the best suited to our needs.

The gate is a simple box culvert, open at the top and with wing walls on the upstream side to prevent any possibility of the water washing behind the walls of the gate. Baffle walls were dropped at each end of the gate for the same reason; i.e., to prevent undermining and the consequent settling of the structure. The structure is of monolithic concrete construction with steel bar reinforcement. The concrete was a one-three-five mix and was mixed by hand on the job using native sand from the beaches of the Sound. The walls and baffles are a minimum of eight inches in thickness while the floor is six.

The structure is five feet wide and four feet deep on inside measurements. Three parallel grooves two inches in depth, one inch wide and eight inches apart were placed in the center of the gate. These were made at the time of pouring. Tongued and grooved boards, one inch by six inches, were cut five feet three inches long so that they could slide up and down in the grooves. When the boards are placed in the grooves the two eight inch spaces between the boards are filled with clay. This system gives an easily removable, and yet water-tight tidegate. There is no seepage through the boards and clay even though the level of the water behind the gate is two to three feet lower than the Sound water level.

At the conclusion of the installation and successful operation of the first gate, the two others mentioned above were built. These gates, in conjunction with the pump, have succeeded in keeping the swamp dry and the residual water in the ditches.

Systems of this nature have been used for years on irrigation projects. They can be used successfully on malaria control projects where other, more orthodox, measures fail when both open-ditch drainage and filling are impractical. Such a system can be used

at a great saving in cost and at a minimum of expense and maintenance. In places where wind velocities are high and constant, a windmill may be used as the motive power for the pump, rather than a gasoline or electric powered model. This has the advantage of reducing maintenance and checking operations. The British and Dutch have used windmills in this method of drainage in the East Indies with considerable success for a number of years and it is a method which is worthy of trial in the coastal marshes and swamps of the south.

NOTICE TO CONTRIBUTORS TO THE JOURNAL

Reprint Orders

In the past there has been some delay in delivery of reprint orders by the Publisher and complaints in this regard have been received frequently by the Editor. The Editor is convinced that the Publisher is making every reasonable effort to fill reprint orders expeditiously, and there is some indication that they will be delivered more promptly in the future. However, the Publisher cannot now promise delivery under 60 days after publication of an article, for he cannot estimate on one day what printers he will have on the next.

Indices for Volume I, II and III

Title pages, content pages, subject indices and authors indices have been prepared and printed for Volumes I and II (together) and Volume III of the Journal. The preparation of mailing lists for the distribution of these indices is a rather complicated matter and they will probably not be mailed until the September issue is distributed.

Publication Status of Contributed Articles

All articles read at the last meeting of the Society and submitted for publication will be published in the current volume of the Journal. In all probability all such articles not already published will be in the September issue. The Editor now has on hand sufficient material for the September and December issues and has a few articles in addition. He is trying to make each issue as timely as possible. He invites your critical comments on the editorial conduct of the Journal and solicits your active interest in the submission of good articles for publication.

MILITARY ASPECTS OF MALARIA CONTROL IN THE FOURTH SERVICE COMMAND*

SAMUEL C. DEWS* AND JAMES H. MORGAN*
Headquarters Fourth Service Command, Atlanta, Georgia
(Received for publication 16 November 1944)

Within the military organization, the responsibility for the prevention of disease is delegated to the Commanding Officers of each installation. This delegation of responsibility makes necessary the enforcement of all phases of preventive medicine, not as isolated programs at selected posts, but rather as a unified program for the protection of all military personnel within the geographical limits of the Command.

With specific regard to the control of malaria, it is the responsibility of all Commanders to initiate and enforce the necessary control measures. The Army Medical Department, as technical advisors to these Commanders, survey the malaria problem, recommend the necessary control measures, and exercise technical supervision over all control. The Corps of Engineers is charged with the responsibility for the execution of mosquito control work on real property, which includes such measures as drainage, filling, larviciding and screening.

The military malaria control program is divided into two phases. First, the individual soldier must be trained and disciplined in personal protective measures. To accomplish this phase a minimum of four hours training is given to all military personnel in the basic principles of malaria control. In the course, the soldier is instructed concerning the military importance of the disease, responsibilities of the unit commanders and the individual, environmental control methods, and individual control measures such as the correct use of repellents, bed nets, insecticides, protective clothing and suppressive drugs. Conferences, demonstrations, training films, phonograph recordings, and other training aids have been prepared to implement this basic instruction.

The second phase involves the protection of military personnel by the actual extermination or control of mosquitoes at each military installation, where their prevalence is a potential source of disease.

When mobilization started in 1940, existing military installations had to be enlarged and many new camps constructed to take care of the rapidly expanding Army. While the seven southeastern states, which constitute the Fourth Service Command, offered many areas with suitable climatic conditions, terrain and other factors

*This paper was presented at the annual meetings of the National Malaria Society in St. Louis, Missouri, 16 November 1944.
*Major, Sn.C., A.U.S.

necessary for establishment of new training camps, these same states contained the heaviest malaria areas of the country. For this reason mosquito control has been and still is a major sanitary and preventive medicine project in this Service Command.

It is hard to realize now the difficult task it was in the fall of 1940 to organize extensive control work, and to anticipate in advance the funds, personnel and equipment that would be needed. While an entomologist and sanitary engineer were assigned to each major post, very few of these officers had previous mosquito control experience and there was no established procedures in the Army for handling a large scale program of this type. Both entomological and epidemiological data on which to base a program were practically nonexistent. In spite of these difficulties, however, a very complete outline was prepared in February, 1941 by the Preventive Medicine Branch of the Service Command Surgeon's Office for reporting results of surveys, and plans recommended for Malaria Control Programs on Military Reservations. This outline, plus a suggested list of tools, equipment and personnel, greatly assisted the posts in making the survey and in submitting an estimate of funds. On the basis of these surveys control programs were instigated at 27 posts during the year 1941.

As mentioned before, very few of the officers on duty at that time had any experience on malaria control work. The entomologist on duty for the most part had no special training in mosquito identification and at that time, no facilities existed at the Fourth Service Command Laboratory to assist in identification work. Consequently, the surveys were hurried and resulted in most part in a program of filling, draining and larviciding of any area that looked as if it would breed mosquitoes, without much regard to species sanitation. Of course, in the haste to provide protection for the troops some unnecessary work was done. Possibly some areas were drained that would never breed *A. quadrimaculatus* and in a few instances breeding areas were created. But the records for the first season show that the majority of the work consisted of cleaning and larviciding. By attacking the problem in this manner, mosquito breeding was successfully controlled over large areas with a minimum of funds and equipment.

During the year 1942, control programs were started at thirty additional posts and in 1943, forty-six additional programs were started. At the present time control programs are underway at 121 military installations of this Command. During these years all new programs have been designed and old programs revised to conform to extensive, continuing epidemological and entomological surveys. Control measures have been carefully designed to conform to these

data as well as to economic aspects based upon the type of installation and its estimated military usage.

A brief summary of the work accomplished shows that over thirty thousand acres have been cleared of underbrush and over eleven million linear feet of channels have been cleared. Four million fet of new ditching have been constructed, of which approximately 900,000 feet have been lined. Approximately 1,500,000 cubic yards of earth were used in filling operation. Over 146,000 acres of water surface have been treated with two million gallons of oil and 61,000 pounds of paris green. Previous to 1 July 1942, this work was accomplished entirely by the Army Medical Department. After that date, work was accomplished by the Corps of Engineers, the Medical Department furnishing recommendations and technical supervision. It was during this period also, that programs were first augmented by the extra cantonment control programs operated by the state health agencies and the MCWA.

With only a few exceptions civilian labor was used in all control operations as the strenuous training program for military personnel did not permit the use of soldier labor. A survey of the work accomplished so far shows the following average labor requirements:

Larviciding	7 man hours/acre
Clearing	88 man hours/acre
Channeling	9 feet/man hour
New Ditching	1.5 feet/man hour
Filling	2 cu-yd./man hour

Now with all this work accomplished, the natural question is, "What good did it do?" In considering the control of malaria, as in all lines of preventive medicine, it is difficult to demonstrate the actual value derived. Since 1940, however, in spite of the constantly increasing strength of command there has been a steady decrease in the number of cases of malaria originating within the Command. During the year 1940, the highest monthly rate was 17.9 per thousand per annum. During the years 1941 to 1944 the highest monthly rates were 6.6, 1.7, 0.9, and 0.2 respectively. In 1941, a total of 940 cases of malaria were reported as originating within the service command, whereas, only 98 cases have been reported thus far in 1944.

While this record is ample justification for the program, the protection afforded by this vector control from the influx of returning carriers is impossible to evaluate. Another factor to be con-

sidered is the experience gained by several hundred young engineers and entomologists who have received invaluable training in malaria control work in this service command prior to their assignment overseas.

Much has been learned from the extensive malaria control program of the Fourth Service Command. The primary lesson that has been demonstrated, however, is that an effective, economical program cannot be enforced within the Army except by close coordination of the activities of the Army medical, engineering and entomological services with full backing from all unit Commanders.

TO THE MEMBERS OF THE NATIONAL MALARIA SOCIETY: THE LIKELIHOOD OF A 1945 MEETING.

The Executive Committee of the Southern Medical Association is making tentative plans for a meeting in Cincinnati, Ohio, from November 19th to 22nd, but will not approach the ODT for permission to hold the meeting until about September 1st. Consecuently it is not advisable to issue the customary call for the annual meeting of the National Malaria Society at this time, but if to be held, the announcement will be made in the September issue of the Journal. Nevertheless, it is desirable to go ahead with plans for a program. Members who are planning contributions to the program are therefore urged to inform the secretary promptly of their intentions, with the title of their subject. The present uncertainty should be no deterrent to their preparation, since in the event there is no meeting, the papers will be submitted to the Editorial Board for consideration for publication in the Journal.

INCIDENCE OF MALARIA AMONG TROOPS IN LIBERIA

LOREN D. MOORE*

Fourth Service Command Medical Laboratory
Fort McPherson, Georgia

(Received for publication 14 November 1944)

The data to be presented are from the Assistant Chief Health Officer's Monthly Health Reports describing the antimalarial activities in Liberia. The period covered is the first year troops were assigned to the area, June 1942 through May 1943. The military population was composed chiefly of colored troops. During the first 8 months the ration of colored to white troops was approximately 5 to 1 which later changed to a ratio of 3 to 1. An advance group arrived in June 1942 and was followed in July by the first echelon. In February 1943 all but 4 units of the first echelon departed and were replaced by the second echelon which arrived in March 1943. At the time the first echelon arrived, no mosquito-proofed quarters, kitchens or mess halls were available and all other mosquito protective measures were at a minimum. By the time the second echelon arrived, mosquito-proofed buildings had been provided and bed-nets, repellents, and insecticides were plentiful.

A survey of the area to be occupied by the troops revealed a high *Anopheles gambiae* density, especially in the nearby native villages. Also, the incidence of *falciparum* malaria was high in this large native population. Thick-film blood surveys showed an 80 to 90 per cent *falciparum* plasmodial index in babies with 50 per cent of them showing gametocytes. The index in young children was 70 per cent with 3 per cent positive for gametocytes. In adults, 30 to 40 per cent were positive for *falciparum* parasites at the time of the examination and approximately 1 per cent of these adults harbored gametocytes. With these findings it was anticipated that the malaria rate would be high in a susceptible population imported into this highly endemic area.

During the first year that troops occupied the area, several of the native villages were moved one-half mile or more from the area in which the troops were housed. To reduce the density of infected mosquitoes in the villages remaining in or near the military area, the native huts were sprayed with insecticide two or three times each week. To reduce breeding in the occupied area, drainage operations were instituted and extended as rapidly as possible. The construction work in the area provided many man-made breeding

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*Colonel, M.C., A.U.S.

places. The weekly oiling of breeding areas with diesel oil reduced the breeding to some extent.

The first echelon was started on quinine suppressive medication prior to their arrival in the area. This suppressive medication was continued for five months or until December 1942. It was estimated that during this time only 50 to 75 per cent took the suppressive medication regularly. Atabrine was not available for suppressive medication. An adequate supply of quinine was available to provide 40 grains per man per week for suppressive medication and to allow sufficient drug for treatment of potential cases. The small amount of atabrine available was used for treatment and as suppressive medication for those individuals sensative to quinine.

An attempt was made to establish an early diagnosis of malaria with bi-weekly thick-film surveys of the troops. The entire force was surveyed 8 times and *falciparum* malaria only was found in 0.9 per cent. Of the total cases surveyed, 0.73 per cent were either in the hospital or were enroute to the hospital within approximately 24 hours after the smears were taken. Of the cases found positive by survey, 0.097 per cent had no symptoms and 0.093 per cent had such mild symptoms that they probably would not have sought medical aid. Therefore, the cases of malaria detected early and brought under observation and treatment amounted to only 0.17 per cent of the total cases surveyed. The detection of this small percentage of malaria did not seem to justify the work involved and the surveys were discontinued.

In this highly endemic area no distinction was made between reinfection and reactivated malaria. The only classification made made (1) initial attacks and (2) subsequent attacks. A case was classified as "initial" if there was no record of an attack or as "subsequent" if it followed a previously recorded attack. Subsequent attacks were further designated as first, second, third, and so on.

Angley, the Malariologist, with the second echelon reports that by September 1943, 67.2 per cent of the troops that had been stationed in the area had had at least one attack of malaria and that 41.2 per cent had had subsequent attacks. In the units comprising the first echelon which left during February 1943, 38.8 per cent had had initial attacks and 16.0 per cent had had subsequent attacks making a total of 54.8 per cent. The second echelon plus those units remaining in the area had had 86.3 per cent initial attacks and 58.1 per cent subsequent attacks for a total of 144.4 per cent.

The low percentage of malaria recorded in the first echelon is difficult to explain since this group lived under field conditions for some time, while the second echelon was housed in adequately

mosquito-proofed buildings. The first echelon was on suppressive medication for six of the eight months they stayed in the area while the second echelon was not placed on suppressive medication until three months after their arrival. About two weeks after the first echelon stopped suppressive medication in December, there was a 10 per cent increase in their malaria rate.

At the time the second echelon arrived, the anopheline density was still high, but as has been stated, the native population in and near the occupied area had been reduced. It was not until June, 3 months after their arrival that atabrine suppressive medication of 1½ grains twice daily on 2 non-successive days each week was started.

Some factors may be considered as contributory to the difference in the malaria rates of the two groups. Early, the lack of development in the area and the long working hours caused many of the men to remain in their tents, and temporary barracks or near their camp after dark. By the time the second echelon arrived a large part of the military area had been cleared, roads had been constructed, transportation was available on the roads and the less strenuous working hours encouraged more men to be out at night and to visit remote areas. Malarial discipline in the first group, although not entirely satisfactory, was very much better than in the second group.

It is interesting to note that the first case of malaria developed on the 9th day after the first echelon landed and that during the next 5 days, 21 more cases were hospitalized making a total of 22 cases in 14 days. The experience of the second echelon was quite different in that no cases appeared until the 14th day when a total of 3 cases were admitted to the hospital.

Table 1 shows that there were 1,236 cases of malaria among the troops during the first year. Of these, 1,206 cases or 97.57 per cent were laboratory diagnosed as *P. falciparum,* 2 cases or 0.16 per cent as *P. vivax* and 1 case or 0.08 per cent as *P. ovale.* Of the 1,026 *falciparum* infections, 13 or 1.05 per cent showed gametocytes. A clinical diagnosis was made in only 14 cases or 1.13 per cent of the total cases.

The withdrawal of suppressive medication contributed to the increase in the total number of cases for December and January. This is substantiated by the lowered rate noted in February. The importation of new troops in March is an influencing factor for the continued low rate. However, by April and in May cases were developing in the new troops. Angley shows that this rate was not reduced until August, 2 months after suppressive atabrine was instituted and after the troops realized the importance of malarial discipline.

TABLE 1

Malaria Parasites Found by Species and Month

PARASITES	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.*	Mar.‡	Apr.	May	Total	Total
P. falciparum							128	110	69	50	272	191	1206	97.57
Ring forms only	7	100	94	37	93	55	3	2			1	1	13	1.05
Gametocytes also					3	3	2						2	0.16
P. vivax							1						1	0.08
P. ovale							1	3				1	14	1.13
Undetermined		2	5	1		1	135	115	69	50	273	193	1236	99.99
TOTAL	7	102	99	38	96	59								

*1st Echelon departed 28 February 1943 ‡2nd Echelon arrived 10 March 1943

TABLE 2

Malaria—Initial and Subsequent Cases—All *Falciparum* Malaria

MONTH	Intial Attack	Subsequent Attacks First	Second	Third	TOTAL
June	7				7
July	100				100
August	82	12			94
September	31	6			37
October	75	19	2		96
November	38	17	2	1	58
December	90	31	12	1	134
January	61	37	10	4	112
February	34	19	16		69
March	31	9	4	6	50
TOTAL	549	150	46	12	757
%TOTAL	72.52	19.81	6.07	1.59	99.99

The distribution of initial and subsequent attacks is shown in Table 1. For a period of 10 months extending from June 1942 through March 1943 there were 757 laboratory diagnosed cases of malaria. Of these, 549 or 72.9 per cent were initial attacks and 208 or 27.48 per cent were subsequent attacks. Of the total number of cases during this period, 150 or 19.81 per cent developed one subsequent attack, 46 or 6.07 per cent had two subsequent attacks and 12 or 1.59 per cent had three subsequent attacks.

For the month of October 21 or 28 per cent of the cases were subsequent attacks while in November, 20 or 52 per cent and in December, 44 or 48 per cent were subsequent attacks. After the suppressive medication was discontinued in December there were 51 or 83 per cent subsequent attacks for the month of January. In February, 35 or 102 per cent of the cases were subsequent attacks and this decreased to 19 or 61 per cent for the month of March.

In summary, a military force taking quinine suppressive medication from July through the middle of December, a period of 5½ months and using moderately satisfactory personal protective measures in a highly endemic malarious area for 8 months developed 38.8 per cent initial and 16.0 per cent subsequent attacks for a total of 54.8 per cent attacks of malaria.

The new force which relieved these troops and the old troops remaining in the area while living under much better sanitary conditions but not taking suppressive medication from March through June, a period of 4 months, developed 86.3 per cent initial and 58.1 per cent subsequent attacks making a total of 144.4 per cent attacks of malaria in 6 months.

GENERAL KIRK REPORTS ON MALARIA EFFECTS

Technical Information Division
Washington, D. C.

(Received for publication 15 June 1944)

Fear due to lack of information can cause more harm than malaria itself, Major General Norman T. Kirk, Surgeon General of the Army, declared in his first public report on the effects of this disease on the individual.

With the prospect of thousands of soldiers returning to this country from malarious regious, General Kirk made an appeal for a better understanding of the problem so the public will realize that, with a few simple precautions, malaria is not a disease that should give undue concern either to infected service men or to their families.

"The soldier who, through ignorance, worries about malaria and the chances of relapses," he said, "will suffer more ill consequences than the man who understands that with proper care this disease is not of serious import from the standpoint of the patient's general health. This very knowledge will contribute considerably to the individual's well-being and fitness."

General Kirk pointed out that families should not consider soldiers infected with malaria a menace to them or the community, provided the malaria sufferer is taking treatment or promptly obtains medical care when symptoms occur.

There are a number of types of malaria, but the two that concern American troops are benign tertian malaria, which is rarely a serious disease, and malignant tertian malaria, which without treatment may be fatal. The latter type is cured by atabrine so that it is not a problem when properly treated. The attacks of malaria which soldiers will suffer after return to this country will be due to benign tertian malaria. This is the one type which is of military significance to American troops.

The service man infected with benign tertian malaria can continue with his usual arduous combat duties as long as he takes the necessary small doses of atabrine. Benign malaria is rarely cured by atabrine. However, this drug suppresses the disease. When a man with benign malaria stops taking atabrine, the usual symptoms—chills, fever, headache, and nausea—may appear.

In the majority of cases the disease has run its course after a man has suffered a few relapses, and no permanent damage has been done. Out of 1,000 cases, about one-third will have only one attack. There will be about 40 out of 1,000 who will suffer ten relapses, and only about one in a 1,000 will have as many as 20 attacks. Relapses become less acute as time goes on.

(Continued on page 121)

ANOPHELINE SURVEYS IN THE FOURTH SERVICE COMMAND[1]

STANLEY J. CARPENTER[2]
Fourth Service Command Medical Laboratory, Fort McPherson, Georgia

(Received for publication 16 November 1944)

Summaries of entomological work, including mosquito surveys in the Fourth Service Command, were presented before the National Malaria Society by King and Kuhns in 1942 and by Carpenter, Kuhns, and Middlekauff in 1943. The work has continued during 1944 in a similar manner to that described in the previous reports. Entomologists and entomological technicians working in camps throughout the area make weekly mosquito collections of four types: resting station, light trap, biting, and larval. Preliminary identifications are usually made at the Posts where the collections are taken and the specimens together with the weekly collection data are forwarded to the Fourth Service Command Medical Laboratory for identification or confirmation. The weekly collections of mosquitoes obtained from carefully selected stations enables the mosquito control workers at the individual camps and at the Service Command Headquarters to make weekly comparisons of the abundance of *Anopheles quadrimaculatus* and other species of mosquitoes of economic importance. The importance of anopheline survey work carried on in this manner has been demonstrated many times at the different posts.

It is proposed to discuss in this paper: (1) anopheline survey methods employed at Army Posts in the Fourth Service Command, (2) mosquito collections from January through September, 1944, and (3) the prevalence of *A. quadrimaculatus* on Army Posts in the Fourth Service Command during 1943 and 1944.

Collecting Methods

Our experience with anopheline surveys and routine mosquito collections in Army Camps in this area during 1942, 1943, and 1944, lead us to believe that each of the four types of collecting, carried out on a weekly basis, contributes a great deal toward the operation of a satisfactory mosquito control program.

Weekly inspections of designated adult mosquito resting stations and larval stations are required of those army installations receiving funds for mosquito control. Light trap and biting collections are recommended as supplementary measures.

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[1]This paper was presented at the annual meetings of the National Malaria Society in St. Louis, Missouri, 16 November 1944.

[2]Major, Sanitary Corps, Army of the United States.

In addition to regular weekly inspections of designated larval and adult mosquito collecting stations, inspectors are urged to make additional miscellaneous larval and adult collections in order to obtain a more complete picture of the mosquito problem in their respective areas. Weekly mosquito collecting is recommended for many of the posts where previous anopheline surveys have shown that malaria control measures are unwarranted at this time. This is of particular importance where changes in conditions favoring the breeding of *A. quadrimaculatus* are likely to occur.

Adult Resting Station Collections

Various types of natural resting stations, including buildings, culverts, bridges, and hollow trees are utilized when available but artificial shelters are frequently necessary in order to have collecting stations properly distributed over the control area. Nail kegs, as used by Smith (1942) in the Tennessee Valley Region and small red boxes as recommended by Goodwin (1942) in Georgia, have been widely employed in army camps in this area. Nail kegs and small red boxes usually yield smaller catches than larger natural shelters, thus making it difficult to determine the relative abundance of *A. quadrimaculatus* particularly where both natural and artificial shelters are being used.

It would be of considerable advantage to have a uniform type of diurnal resting station for use throughout the Service Command. Uniform adult collecting stations properly utilized would enable workers to more satisfactorily interpret densities of *A. quadrimaculatus*. An artificial shelter in the form of a privy-like building has been utilized in several camps in this area and yields much larger catches than smaller artificial shelters previously used. (Carpenter, in press). The privy-like shelter is 4 feet square and 7 feet high. The sides and roof are made of close-fitting boards cut from unpainted, weather-beaten scrap lumber. The front is open to a height of approximately 30 inches above the ground to provide an entrance for the collector. When located in unshaded or partially-shaded areas, a curtain of burlap should be hung over the front opening of the building to extend to within 6 to 8 inches of the ground.

Light Trap Collections

The New Jersey type mechanical light trap was used as a supplementary mosquito collecting device in 65 camps during 1944. These traps are operated on a schedule of three nights each week (Monday), Wednesday, and Friday). A comparison of catches of *A. quadrimaculatus* taken in diurnal resting stations and with the New Jersey trap, using the average per collection for all resting station and trap records, has been made for the period of May 15th

to October 1st, 1944, and no correlation was evident. It is the opinion of the writer that a better picture of the relationship between catches of *A. quadrimaculatus* taken from resting stations and by means of light traps can be obtained when only camps employing both methods are considered and when weather data are fully utilized in the study. An analysis of these data is under way but has not been completed. Even if no true correlation exists for catches of *A. quadrimaculatus* taken by these methods it is felt that the trap collections do contribute worthwhile information toward obtaining a more complete picture of the mosquito population in an area.

Biting Collections

Records of the number of mosquitoes attempting to feed on collectors give direct information on the kinds that are causing annoyance and their relative abundance. Night-biting collections are made weekly at several points in the different camps when possible. Daytime-biting records of temporary pool-breeding species of *Aedes* and *Psorophora* are frequently obtained in areas where training may be hindered by the biting of these mosquitoes. Biting records are of particular value for furnishing information or answering criticisms as to the actual degree of annoyance caused by both daytime and night-time biting species. Biting collections of mosquitoes were received from 43 camps in this Service Command during the first 9 months of 1944.

Larval Collections

A system of larval collections or inspections was instituted at the beginning of the program at the different posts to determine: (1) water areas producing *A. quadrimaculatus* and other important species, (2) need for larval control, (3) the effectiveness of larval control measures, and (4) changes in breeding conditions that may occur.

Individual lakes, ponds, sections of streams, areas of small pools and other specific larval habitats have been designated as larval stations or collecting areas at each post. These areas are carefully inspected at least once each week and larval collections are obtained for identification where breeding is found.

The saving in labor and material necessary for carrying on efficient mosquito control has been demonstrated wherever the information obtained by larval inspectors was fully utilized. The importance of intensive searches for larvae is further illustrated by the finding of a larval specimen of *Anopheles albimanus* at Boca Raton Field, Florida, during the summer of 1944. During the week of May 14th to 20th a total of 125 dips was taken from one larval station, consisting of a short section of a canal extending between two bridges at Boca Raton Field and two fourth instar larvae were collected, one *A. quadrimaculatus* and one *A. albimanus*.

TABLE 1

Mosquitoes Collected in the Fourth Service Command from January through September, 1944.

Months	January	February	March	April	May	June	July	August	September	Total
Number of Posts	62	49	68	81	107	110	123	117	116	132
Number of Species	34	30	40	48	50	52	51	52	47	57
Number of Larvae	4,334	7,901	15,996	18,490	19,236	19,625	22,177	16,985	16,336	141,020
Number of Adults	7,094	2,731	8,294	23,051	54,893	74,895	80,034	76,668	70,918	398,578
A. quadrimaculatus (percent of adults identified)	3.6	7.2	4.6	3.0	3.6	11.2	7.1	6.2	7.2	6.9

Collections During 1944

Mosquito collections from all Army posts in the Fourth Service Command are sent to the Fourth Service Command Medical Laboratory each week for identification, or confirmation of identifications made locally. A summary of all mosquito identifications made at the Laboratory from January through September, 1944, is given in Table 1. The number of posts submitting specimens during 1944 varied from 49 in February to 123 in July. Collections were received from 132 different posts during the first 9 months of 1944. The number of species of mosquitoes identified varied from 30 in February to 52 in August. 57 species were represented in the collections from January through September. A total of 539,598 adult and larval specimens of mosquitoes were collected and 6.9% of adult specimens taken were *A. quadrimaculatus*. Table 2 shows the number of collections made and the total number of adult specimens of *A. quadrimaculatus* taken in diurnal resting stations, in light traps, and in biting collections.

TABLE 2

A Summary of Collections of *A. quadrimaculatus* in the Fourth Service Command from January through September, 1944.

Month	Diurnal Resting Stations		Light Traps		Night Biting Collections	
	No. Coll.	No. *A. quad.*	No. Coll	No. *A. quad.*	No. Coll.	No. *A. quad*
January	1,407	244	342	14	26	0
February	1,403	162	432	36	22	0
March	1,489	336	798	36	78	12
April	2,998	570	1,274	115	150	0
May	3,960	1,690	1,736	307	343	16
June	5,675	7,646	2,420	728	490	51
July	4,611	5,374	1,851	329	405	19
August	4,496	4,210	1,829	589	531	8
September	4,691	4,020	1,728	1,082	503	20
Seasonal Total	30,790	24,252	12,410	3,236	2,548	126
Average per Coll.		.77		.26		.05

Prevalence of A. quadrimaculatus During 1943 *and* 1944

A comparison of weekly collections of *A. quadrimaculatus* made comparison of weekly collections of *A. quadrimaculatus* made in diurnal resting stations during the period January through September, 1943, and 1944, is shown in Figure 1. The heavy population of *A. quadrimaculatus* encountered in late June and July, 1943, was due largely to a very heavy increase of this species occurring in the camps located in Mississippi. It is interesting to note that populations of *A. quadrimaculatus*, based on weekly collections from resting stations at army camps, were heaviest during late June and July for both 1943 and 1944.

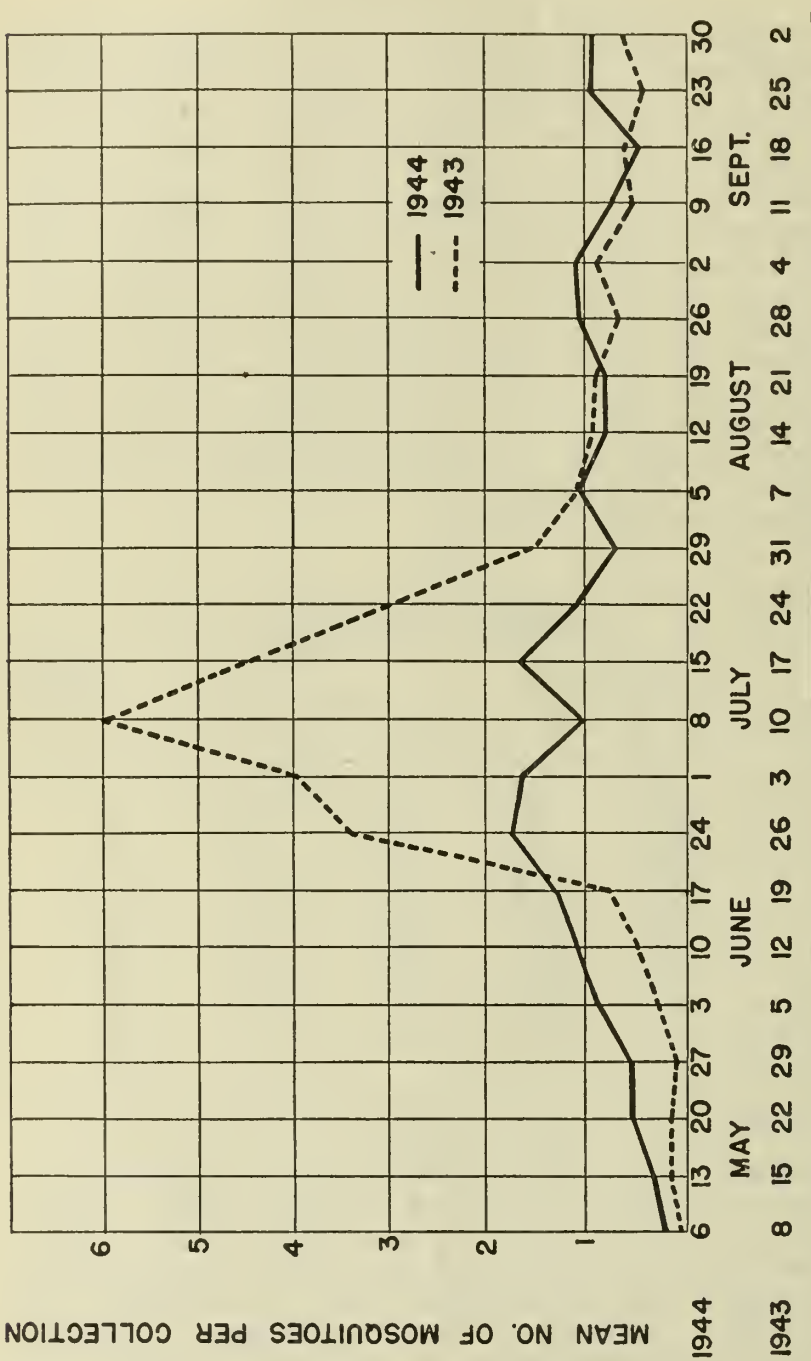

Fig. 1. A comparison of collections of *Anopheles quadrimaculatus* taken in resting stations in Fourth Service Command, 1943 and 1944.

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REPORTS ON MALARIA EFFECTS

(Continued from page 114)

When attacks do occur, the symptoms are rapidly relieved and all progress of the disease is quickly suppressed if the proper medical care is given the patient. In most cases this can be accomplished within 48 hours, according to General Kirk.

"As a result of prompt and efficient action," he said, "attacks of malaria by themselves cause only brief incapacitation and result in no permanent damage to the body."

General Kirk stressed the point that malaria can be spread only by the *Anopheles* mosquito. Even if a man is infected, the *Anopheles* mosquito cannot transmit the disease unless it has bitten the victim during a relapse and before medical treatment has been secured. In most parts of the United States there is little likelihood of this since mosquito control measures are adequate.

Infected individuals who are not taking regular suppressive medication are particularly subject to relapses if they engage in strenuous work, or if they suffer from exposure, or if they indulge in drinking to excess.

One phase of malaria treatment that causes concern to many victims is the yellow color the skin takes on as a result of using atabrine. This color is not due to jaundice or any other malfunctioning of the body. It is caused directly by the yellow color of atabrine which is deposited in the skin. The yellowness will disappear a few weeks after the use of the drug is discontinued.

Deaths due to malaria since the beginning of the war have been rare. They are nearly always associated with other diseases and with circumstances which cause delayed or inadequate treatment, Army records show. In the early stages of the Pacific war, malaria did more damage to American soldiers than Jap bullets—in disabling troops, but not in killing them.

SUGGESTIONS FOR THE PREPARATION OF MANUSCRIPTS

Manuscripts intended for publication in the Journal of the National Malaria Society should be prepared in accordance with the style and rules set by the Editorial Board. Failure to conform to these rules will delay final publication because priority in publication is based upon the date of final acceptance of the manuscript in satisfactory form.

The manuscript must be clearly typewritten (not a carbon copy), double-spaced throughout, on one side of the paper only. It must be an original contribution which has not been published elsewhere, either wholly or in essential part. The author's complete address, to which proof is to be sent, should appear on the first page. Pages should be numbered consecutively, including separate pages for each table, chart, or illustration. Footnotes should be inserted in the text, between continuous lines, immediately below the sentence in which the footnote reference occurs. Footnotes should be numbered consecutively unless limited in number to one or two notes indicated by asterisks on the first page.

The title should be brief, descriptive of the subject matter, and self-explanatory. Author's names and addresses should be given but titles such as doctor, professor, or colonel, and academic or honorary degrees should be omitted.

The paper should be well-organized, including a brief introduction, explanation of methods, a discussion of results, and a summary or statement of conclusions. The body of the text should be broken up by subheadings. Acknowledgments should be brief and are conveniently placed in a footnote or in a separate paragraph following the introduction.

Literature citations in the text should be by author followed in parentheses by the year of publication of the references; thus, "Hewitt (1939a) observed. . . ." References should be arranged alphabetically at the end of the article in a section entitled "Bibliography," "Literature Cited," or "References."

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A DIRECTIONAL MOSQUITO BARRIER TRAP[1]

WILLIAM M. GORDON AND EUGENE J. GERBERG[2]

(Received for publication 18 November 1943)

During the fall of 1942, the writers made a survey of the mosquito breeding conditions about the U. S. Naval Air Station at Corpus Christi, Texas. Enormous numbers of *Aedes sollicitans* were found on the Gulf islands (Padre and Mustang) that lie three to four miles off shore from the U. S. Naval Air Station. In order to limit possible control operations to the exact areas of mosquito breeding, we endeavored to ascertain from which direction the main flights of mosquitoes were originating. To accomplish this, five mosquito barrier traps were set up in the station. Since prevailing winds come from the southeast, and that was the suspected direction of mosquito flight, the traps were located on the south and east sides of the station, at one-half mile intervals.

The barrier traps (Fig. 1) were designed and constructed to indicate the direction of mosquito flight, and to capture samples of the mosquito population that were blown or flew to the station. The wire screens (18 mesh copper wire) are supported by grooved arms, nailed to a 4 x 4 inch post. These arms are grooved to facilitate the removal and changing of the wire screens. There are 400 square inches of exposed screen surface on each face of each screen frame. The center of each screen was approximately 5½ feet above the ground. In order to provide a catching surface, the screens were coated with Tree Tanglefoot, a nondrying varnish, which can be applied by means of a paint brush. Light applications should be made, so as not to close up the mesh in the screen, and at least two coats are needed each week.

The value of the screened frames over glass or other solid catching surfaces is that the screens offer very little wind resistance, therefore not appreciably "reflecting" air motion.

The arms or vanes of the trap, which form 90° angles, were installed to point toward the northeast, southwest, southeast, and northwest. Thus two screen surfaces faced each wind direction, forming a barrier plane. If mosquitoes were taken only on the southeast side of the southwest screen, and on the southwest side of the southeast screen, the mosquitoes must have come from a

[1]This paper was presented at the annual meetings of the National Malaria Society in Cincinnati, Ohio, 18 November 1943.

[2]The senior author was a Lt. (jg) and was station Entomologist, U. S. Naval Air Station, Corpus Christi, Texas. He was killed in action in New Guinea 3 October 1944. The junior author, 2nd Lt., Sanitary Corps, U. S. A., 609 Malaria Survey Detachment, Camp Plauche, New Orleans 12, Louisiana, was formerly Assistant Entomologist (R) with U. S. Public Health Service.

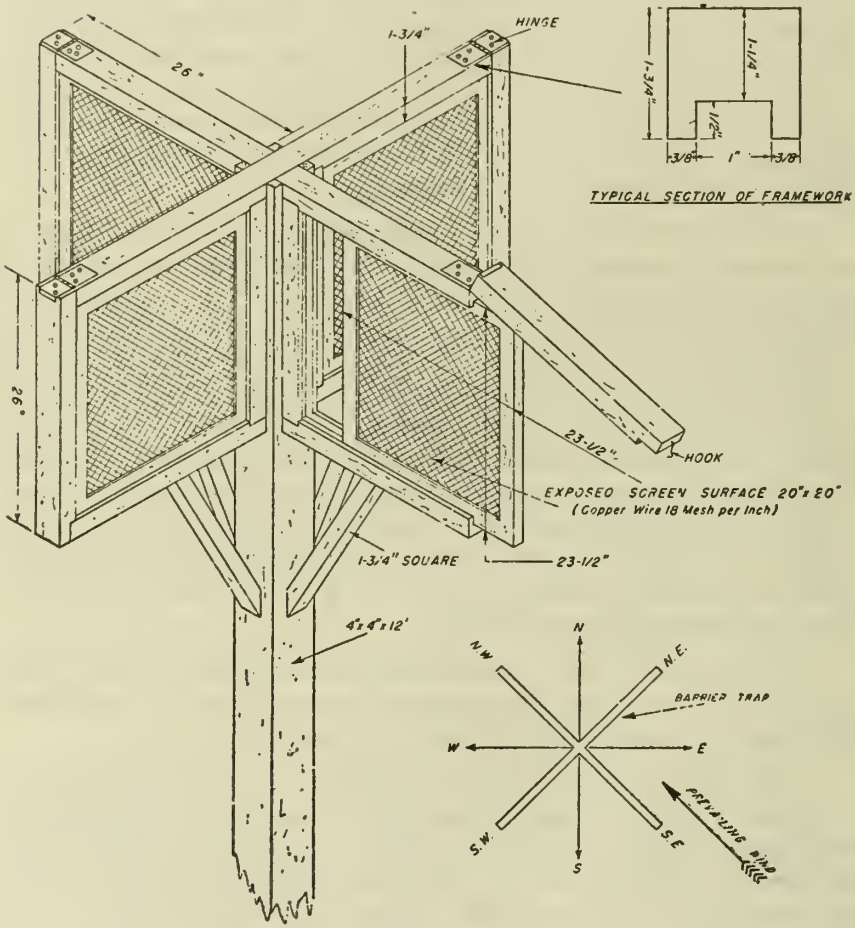

Fig. 1. Mosquito Barrier Trap

true south direction. If the prevailing winds happened to have been from the north, we could assume that mosquitoes were breeding south of the trap and were bucking the wind. The barrier trap does not necessarily serve as a complicated weather vane; instead, it indicates flight direction, regardless of the prevailing winds.

The traps were checked each day, and the majority of the mosquitoes captured were identified in the field. The results were tabulated on a daily record form and summarized at the end of the month. Though the traps were in operation only a short time, the following results were obtained:

1. Five species of mosquitoes were captured by the barrier traps. They were, in order of abundance, *Aedes sollicitans, Anopheles quadrimaculatus, Aedes taeniorhynchus, Psorophora confinnis,* and *Culex quinquefasciatus.*
2. 58.8 per cent of the total catch was *Aedes sollicitans.*
3. 88.0 per cent of the mosquitoes were taken on the southeast side of the southwest and northeast screens.

During the period that the barrier traps were in operation, there was little or no mosquito breeding for one-half mile in any direction from the traps. On the other hand, *Aedes sollicitans* were very abundant on the islands previously mentioned. Two electric mosquito traps (New Jersey type trap Model No. 50) were operated in the vicinity of the barrier traps. *Aedes sollicitans* amounted to 51.3 per cent of their total catch, which is a difference of only 7.5 as compared with the barrier traps catch.

Summary

A mosquito barrier trap utilizing screened panels and which serves as a directional indicator of mosquito breeding, is described. The screen frame increases the accuracy and efficiency of the barrier trap because the air movement is not appreciably "reflected" by the screening. Five species of mosquitoes were collected, of which *Aedes sollicitans* made up 58.8 per cent of the total catch. This compared very favorably with two electric mosquito traps placed in the vicinity. Of the mosquitoes collected, 88 per cent came from the southeast, which was the direction from the largest breeding area.

SUGGESTIONS FOR THE PREPARATION OF MANUSCRIPTS

(Continued from page 122)

Hewitt, R.

1939a. Experimental erythroblastosis in carnaries and its effect on infections with *Plasmodium cathemerium*. Amer. Jour. Hyg., 29:135-148.

1939b. Splenic enlargement and infarction in canaries infected with a virulent strain of *Plasmodium cathemerium*. Amer. Jour. Hyg., 30:39-64.

If reference is made to only one or two articles, these may be cited as footnotes as follows: "Soper and Wilson[1] observed. . . ."

[1]Soper, F. L. and D. B. Wilson. Species eradication. A practical goal of species reduction in the control of mosquito-borne disease. Jour. Nat. Malaria Soc., 1:5-24, 1 fig., 1942.

Tables should be numbered in a separate series from text figures. They must be arranged so that, regardless of length, the number of columns is reduced to a minimum. Examine a page of the Journal with its 4½ inch by 7½ inch type page and put yourself in the position of the editor who must fit your table or illustration on the page. Tables and illustrations should be planned for reduction to page width in all but the most unusual cases because tables placed lengthwise of the page are awkward and are usually wasteful of space. Clear, concise headings should be prepared for tables.

Illustrations are a valuable addition to most scientific papers and their use should be encouraged. Illustrations may be of two types, line drawings or half-tones. Line reproduction requires sharply contrasting black ink drawings or graphs on a white background. Graph paper with a blue cross-hatching should be used because blue lines do not reproduce in line reproduction. Numbers or letters are a permanent part of the final illustrations and should be done neatly. All illustrations of this type should be made large enough to allow for one-third or one-half reduction.

Line cuts or zinc etchings can be printed on the regular paper of the Journal. Photographs must be reproduced by the half-tone process. This is more expensive and requires a hard glazed surface paper for satisfactory reproduction. Consequently, extra sheets of paper must be tipped in by hand for half-tone plates. This costs so much that authors are required to pay the total cost for half-tone reproductions. All copy for illustrations (or engravings if these are supplied by the author) should be clearly labeled on the back with the name of the author and the number of the illustration as it appears in the text. Original drawings and engravings will be returned to the author upon request, otherwise they will be destroyed after six months.

STUDIES ON IMPORTED MALARIAS: 1. ABILITY OF DOMESTIC MOSQUITOES TO TRANSMIT *VIVAX* MALARIA OF FOREIGN ORIGIN*

MARTIN D. YOUNG, TRAWICK H. STUBBS, JOSEPH A. MOORE, FREDERICK C. EHRMAN, NEWTON F. HARDMAN, JOHN M. ELLIS AND ROBERT W. BURGESS

United States Public Health Service, Columbia, South Carolina

(Received for publication 14 November 1944)

In the fall of 1943, with the advice and approval of representatives from the Army, Navy, and certain other agencies interested in malaria, the Public Health Service in cooperation with the Army established the Imported Malaria Studies Program. This program is under the professional direction of the Malaria Investigations Office of the National Institute of Health, but is financed and staffed by the Office of Malaria Control in War Areas. Appreciation is expressed for the splendid cooperation, which made the program possible, of the Office of the Surgeon General of the Army and the staffs of the following Army General Hospitals: Letterman, Dibble, Harmon, Hammond, Moore, Oliver, Stark; also the Fort Jackson (S. C.) Station Hospital and the Naval Hospitals at Charleston, South Carolina, and Oakland, California.

The objectives of the program were concerned primarily with obtaining information related to the emerging malaria problem, as follows:

1. To determine the ability of the imported malarias to infect American anophelines and to be transmitted by them.
2. To gather information on the parasitology and other characteristics, and to distinguish, if possible, between strains.
3. To evaluate the findings and suggest their implications upon control measures.

In addition to the headquarters laboratory in Columbia, S. C., which had access to one Navy and four Army hospitals, laboratories were established in space provided by the Army in Letterman General Hospital, San Francisco, and Harmon General Hospital, Longview, Texas. (The last week in September a similar laboratory was established at Moore General Hospital, Swannanoa, N. C.). At each laboratory an insectary is maintained, with *Anopheles quadrimaculatus* Say, or *Anopheles maculipennis freeborni* Aitken, as the standard testing species. Colonies of other species are now established and several experiments have been run, but only these two species are reported here.

This report is the first of a series resulting from these studies and includes work accomplished through September 30, 1944.

*This paper was presented at the annual meetings of the National Malaria Society in St. Louis, Missouri, 14 November 1944.

Methods

The principal procedures involved in the work are those which have been developed during the past few years in the Columbia laboratory*. In general, they consist of feeding mosquitoes (preferably 100 or more) on relapsing cases of malaria, dissecting them at intervals to determine rates of infection (an infection is defined as the presence of oocysts, sporozoites, or both), and feeding selected lots on neurosyphilitic patients requiring malaria therapy in order to demonstrate transmission. These procedures were pictorially presented in the February, 1944, Monthly Report of Malaria Control in War Areas.

Observations

On 151 different patients 160 lots of mosquitoes have been fed. The origins of the cases studied, as nearly as could be determined, are summarized in Table 1. All of these cases were *Plasmodium vivax*. Only 3 *falciparum* cases were encountered and these are not included in this report.

Table 1.—Probable Origin of Infections Studied

South Pacific Area		136
Guadalcanal	96	
New Guinea	33	
Other	7	
Mediterranean Area		18
Europe	9	
Africa	9	
South American Area		6
Trinidad	6	
Total Lots Fed (On 151 different patients)		160

In the Texas and California laboratories cases were more carefully selected so as to use those showing gametocytes in the peripheral blood, whereas at Columbia feedings were usually made on all cases showing parasitemia. The summaries of the lots fed as compared with the infected lots must be interpreted in light of this fact. Table 2 shows lots of mosquitoes applied and the number infected expressed in percentages. A lot was considered infected if it showed one or more infected mosquitoes.

*Burgess, R. W. and Young, M. D. Methods of Rearing and Feeding *Anopheles quadrimaculatus* Say up on Balarious Patients. Jour. Nat. Mal. Soc., 3: 241-247. 1944.

From Table 2, it is interesting to observe that the rate of infection according to lots is about the same for the three widely separated areas.

TABLE 2
Number of Lots Fed and Percent Infected According to Origin of the Infections

	Columbia (*A. quad.*)		Texas (*A. quad.*)		California (*A. free.*)		Total	
Total	Fed. 68	Inf. 54%	Fed. 31	Inf. 77%	Fed. 61	Inf. 77%	Fed. 160	Inf. 68%
Pacific Area	45	47%	31	90%	60	78%	136	68%
Mediterranean Area	17	71%	—	—	1	0%	18	67%
South America	6	67%	—	—	—	—	6	67%

Table 3 shows the total numbers of mosquitoes fed, dissected, and found infected, with percentages.

Among the infected lots, the total number of infected *A. quadrimaculatus* were 959 out of 2,489 or 38.5 percent while the *A. m. freeborni* showed 1,358 infected out of 2,581 dissected, or 52.6 percent. It is also noted, however, that among the *A. quadrimaculatus* at Columbia there were 460 out of 1,072, or 42.9 percent infected, whereas in Texas there were 499 out of 1,417, or 35.2 percent infected.

TABLE 3
Summary of 160 Mosquito Infection Experiments on 151 *vivax* Malaria Patients

	Columbia (*A. quad.*)	Texas (*A. quad.*)	California (*A. free.*)	Total
Total lots fed	68	31	61	160
Total mosquitoes fed	5,599	2,847	8,888	17,334
Infected lots	37	24	47	108
Mosquitoes fed	3,138	2,389	7,032	12,559
Mosquitoes dissected	1,072	1,417	2,581	5,070
Mosquitoes infected	460	499	1,358	2,317
Percent infected	42.9	35.2	52.6	45.7

There are many factors influencing the figures given for the infected lots of mosquitoes other than the susceptibility of the mosquitoes, the most obvious being the number of mature gametocytes in the peripheral circulation. The influence of this factor, although definitely affecting these data, is not used here as a criterion in separating lots. Since the gametocyte threshold necessary for infection has not been accurately determined, and since other factors have an influence, we have separated lots simply on the basis of whether or not any infected mosquitoes were found.

Whether the difference in the infection rates of the *A. quadrimaculatus* and *A. m. freeborni* is significant has not been tested adequately. Observations are now under way to elucidate this point.

To prove the actual transmission of these malarias, infected mosquitoes were applied to neurosyphilitic patients. Arrangements were made with the various hospitals to use these malarias in the treatment of neurosyphilis. The summary in Table 4 shows the results of the attempts to transmit them to white patients. Additional attempts made on Negro patients are not included in this summary because of the possible potential difference in immunity. The Negro transmissions will be handled as separate experiments.

TABLE 4

Summary of Attempts to Transmit Imported *P. vivax* to Neurosyphilitic Patients.
Infected Mosquitoes from 32 cases were fed on 59 patients.

	Pacific		Mediterranean		Total	
	Attempts	Successes	Attempts	Successes		
Infected Mosquito Lots						
A. quad.	18	11	5	3	23	14
A. freeborni	9	7			9	7
Total	27	18	5	3	32	21
Patients						
A. quad.	45	33	5	3	50	36
A. freeborni	9	7			9	7
Total	54	40	5	3	59	43

On a basis of comparison with American strains, the imported cases are compared with feedings on the St. Elizabeth's strain of *P. vivax*. No series of cases of indigenous malaria is available for comparison. An attempt was made along this line, but too late in the season, and only three *vivax* cases originating in the United States were tested. Table 5 shows figures for infected lots and total numbers of infected mosquitoes, comparing St. Elizabeth's *P. vivax* in *A. quadrimaculatus* to foreign *P. vivax* in *A. quadrimaculatus* and *A. m. freeborni.*

TABLE 5
Mosquito Infecting Experiments Showing
Comparison of Foreign with St. Elizabeth's strain of *P. vivax*

	St. Elizabeth	Foreign	
	A. quad.	*A. quad.*	*A. freeborni*
Infected lots	108	61	47
Mosquitoes dissected	2,277	2,489	2,581
Mosquitoes infected	1,128	959	1,358
Percent infected	49.5	38.5	52.6

Summary

1. One hundred sixty (160) lots of mosquitoes were fed on 151 patients relapsing with *Plasmodium vivax* malaria of foreign origin (99 lots of *A. quadrimaculatus* on 96 patients and 61 lots of *A. m. freeborni* on 55 patients). Infections were produced in 108, or 68 percent of these lots.

2. Of 17,334 mosquitoes fed on these foreign cases, 12,559 were in the 108 infected lots. Of the latter, 5,070 were dissected and 2,317, or 45.7 percent revealed either oocysts or sporozoites or both (959 out of 2,489 *A. quadrimaculatus,* or 38.5 percent; and 1,358 out of 2,581, or 52.6 percent in *A. m. freeborni*). Of 108 lots of *A. quadrimaculatus* fed on cases of St. Elizabeth strain of *P. vivax,* 1,128, or 49.5 percent, of 2,277 dissected were infected.

3. From 32 imported malaria cases, transmission to 59 white patients was attempted. Twenty-one (21) of these strains produced infections in 43 patients.

Conclusions

On the basis of the evidence so far, the following conclusions appear to be justified:

1. *Plasmodium vivax* malaria contracted by soldiers in foreign countries (South Pacific, Mediterranean, and South American areas) which relapses after their return to this country is infective to the native malaria vectors, viz., *Anopheles quadrimaculatus* Say and *Anopheles maculipennis freeborni* Aitken.

2. These mosquitoes infected by the imported *vivax* malaria can transmit the disease by biting a susceptible person.

3. Control measures are as necessary for imported malarias as for native malarias. Military personnel relapsing with imported malarias in an area where malaria vectors are present would offer possibilities for transmission to the population similar to a corresponding number of native malaria cases.

BOOK REVIEWS

The Mosquitoes of North America. Their Structure and Habits, Study and Identification, How They Carry Disease, Methods of Control. Robert Matheson, Professor of Entomology, New York State College of Agriculture at Cornell University. Price, $4.00. Second Edition, Revised and Amplified. Pp. 272 with 33 plates. Ithaca, New York: Comstock Publishing Company. 1944.

In the first edition of his Handbook, published in 1929, Doctor Matheson presented the most concise and understandable treatise on the biology, classification and principles of control of North American mosquitoes which had appeared up to that time. This second edition presents a complete revision, and much new material has been added to bring it up to date. Its appearance will be welcomed by all those whose activities include any phase of mosquito work.

As in the first edition, the subject matter is treated in two parts. Part I, entitled "Mosquitoes, a Comprehensive Survey," includes five chapters as follows:

Chapter I. Characteristics of Mosquitoes.

Chapter II. The Biology of Mosquitoes.

Chapter III. Mosquitoes in Relation to Human Welfare.

Chapter IV. The Problem of Mosquito Reduction, and

Chapter V. How to Study, Collect, Rear, and Preserve Mosquitoes.

The discussions in these chapters are rather condensed, yet each topic dealt with is treated in sufficient detail to give the user a grasp of the essentials.

In Part II, entitled "A Systematic Account of North American Mosquitoes," new keys to genera and species have been presented. As far as possible, all of the mosquito species occurring in North America, excluding Mexico, are described and brief notes given on their biologies, habits and distribution. An innovation is the inclusion of a discussion of the subfamily *Chaoborinae* (*Corethrinae* of authors). The characters for separating species in the keys are those at present believed to be most reliable. It is anticipated, however, that users not acquainted with the ranges of variation in these characters still will have some difficulty using them. The species descriptions have been painstakingly prepared with emphasis on diagnostic characters. The notes on specific biologies and distribution are, in most cases, quite brief and general. Fuller discussions of these no doubt would be welcomed by most users of the book. However, as the author states, a careful selection of material was necessary in order to keep the size of the book within prescribed limits.

Of interest to the systematist is the author's treatment of the genus *Anopheles*. He has accepted full specific status for the species of the *crucians* complex, *crucians*, s. s., *bradleyi* and *georgianus*, and without discussion has given specific rank to *franciscanus* in the *pseudopunctipennis* complex. No mention is made of *boydi* Vargas, considered by Aitken as a synonym of *franciscanus*. Also, it might have been desirable to devote a few more lines to synonomy of some of the more common species, particularly *Aedes aegypti*, *Culex pipiens* and *C. quinquefasciatus* even though references are given as to where this information can be obtained. In the

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THE USE OF HOUSE MOSQUITO-PROOFING AS AN EMERGENCY MALARIA CONTROL MEASURE IN THE KENTUCKY RESERVOIR

C. W. Kruse and F. E. Gartrell

Public Health Engineering, Health and Safety Department,

Tennessee Valley Authority, Wilson Dam, Alabama

(Received for publication 17 November 1944)

Introduction

The Kentucky Project, lowermost and largest of the main river projects of the Tennessee Valley Authority, has created a lake with an area of 159,000 acres and shoreline of 2200 miles at normal pool elevation 359′. The project is located in an area of known malaria endemicity. The flat topography of the alluvial flood plain in the region of this project and the size of the impoundage, which limits the scope and character of water level management, combine to present a potential malaria problem not heretofore encountered on any of the other impounded water projects in the Tennessee Valley. The malaria control experience gained from the operation of the first main river projects completed by the Authority served as a basis for the comprehensive malaria control program developed for the Kentucky Project. A preliminary report by Bishop and Gartrell (1943), described briefly the principal malaria control features of this project which include dewatering by means of pumps and levees, shoreline grading, land use restriction adjacent to certain portions of the reservoir and supplementary control measures such as mosquito proofing, larvicidal operations, drainage, and shoreline maintenance.

Construction of the dam was begun in 1938 with reservoir preparation not being initiated until 1941. The original construction schedule called for impoundage during the winter of 1944-1945. but because of wartime needs for electric power from the project, the date of filling was advanced to December 1943. During the spring of 1943 the cofferdams were flooded out by backwater from the Ohio River, delaying completion of the dam until the late summer of 1944. Wartime power requirements necessitated partial filling of the reservoir as soon as possible and construction of highways, railroads, and malaria control projects in the reservoir which would not be completed before the fall of 1944 would not permit filling above elevation 350′, nine feet below the normal pool. It was realized that filling of the reservoir during the summer was contrary to practice set out by state regulations governing the impounding of water and the Health and Safety Department

*This paper was presented at the annual meetings of the National Malaria Society in St. Louis, Missouri, 17 November 1944.

was requested to develop, with the assistance of the state health departments concerned, an emergency malaria control system which would permit partial filling of the reservoir during the summer of 1944. A careful appraisal of all the factors having a bearing indicated that a successful control of *Anopheles quadrimaculatus* under such emergency situation could not be anticipated.

Past experience has demonstrated the effectiveness of house mosquito proofing as an economical measure against malaria transmission, (Watson and Maher, 1940; Kiker and Breedlove, 1941; Watson and Rice, 1941; Kiker, 1941). This measure had been employed previously in connection with the summertime filling of two reservoirs in Alabama, (Biennial Reports Alabama State Board of Health 1928-29). On the basis of this experience mosquito-proofing of all dwellings within one mile of the 350′ contour was proposed as an emergency malaria control measure to permit summertime filling of the reservoir, to be supplemented by routine house spraying if conditions indicated. The Kentucky and Tennessee Departments of Public Health approved the proposal and agreed to cooperate in the execution of the mosquito-proofing program. The Construction and Maintenance Division of the Tennessee Valley Authority, which was responsible for other reservoir construction work in the area was called on to execute the program according to plans and specifications of the Health and Safety Department.

Survey methods and construction procedures were dictated by the short time that was available for completion of the program. which was less than nine months. Preliminary estimates indicated 1200 houses in nine counties to be mosquito-proofed. Modifications in designs and procedures were developed to meet wartime restrictions on available materials and to expedite the field application of the program. This paper describes the program as it finally evolved, dealing specifically with survey methods used, bills of material and specifications, and shop and field installation procedures.

Estimates of Quantities

In our past mosquito-proofing operations a close estimate of materials was obtained by completely surveying house to house and preparing tabulations from floor plan sketches showing the requirements for mosquito-proofing. Unfortunately much time and travel are consumed in this practice and expected slow delivery of materials, especially lumber, demanded that requisitions be in at the earliest possible dates. The Authority's past knowledge of mosquito-proofing requirements obtained from the Wheeler and Guntersville Reservoir programs greatly reduced the chances of error so that the complete material survey was not deemed necessary. In-

stead, a sample representing actually 7% of the total houses was selected from the maps at random over the entire area. The information from the complete floor plan sketches of 86 houses was tabulated and totaled and results inflated to cover the total number of houses estimated to require mosquito-proofing. A 10% safety factor was added to the items to provide a margin for any errors in the total number and type of houses actually encountered in the field. It is interesting to report that the entire operation of surveying and preparing specifications and bills of materials for purchase requisitions was started and completed within a week, whereas a complete house to house material survey would have required at least 12 party weeks and some 10,000 miles of car travel. Further, it developed that the estimates of materials were adequate and that no reorders were required to complete the proposed program.

Mapping and Door Survey

The standard malaria survey maps of the Kentucky Reservoir showing numbered houses, zones, and other necessary malaria control information were being developed and could not be made available for the emergency program; and it was indeed fortunate that the Tennessee Valley Authority had available suitable maps of the Kentucky Reservoir area. Several sets of Flowage Topography Maps scale 1" equals 2000' were obtained for the mosquito-proofing program. These maps not only show the reservoir contours, but roads and houses in the surrounding region. The Maps and Survey Division in Chattanooga projected the purchase line on the maps in order that houses moved and destroyed could be eliminated, and, also, added the one-mile mosquito flight range from the 350' and 359' contours to define the extent of the proposed work. Six areas, (Bishop and Gartrell, 1943), mostly in the lower reservoir area, had already been set up for permanent mosquito-proofing and these areas were completed along with the emergency mosquito-proofing. Basically, the only difference in the temporary and permanent mosquito-proofing was that permanent work extended out some distance farther to include all houses one mile from the normal pool, 359' elevation, and in the type of permit obtained from the owner which provided for year to year maintenance. The procedure of field checking houses on the map before numbering was not feasible, therefore, it was decided to number on the map all houses shown throughout the entire one-mile flight zone from the normal pool in order that the number employed could serve the permanent malaria survey map. After eliminating all houses below the purchase line, a consecutive numbering system was employed beginning on the right bank of the reservoir at the damsite. Obviously, the house locations shown on the Flowage Maps were some-

times in error and incomplete, principally due to the movement of families from the inundated and purchased portions of the Kentucky Reservoir to new locations. For this reason five numbers out of fifty were intentionally reserved for correcting the numbering systems in the field. That is, houses were numbered on the map beginning 1 to 45 and then instead of the next house being 46 the number 50 was used, to permit a slack of 5 numbers for assignment to new and relocated houses. These reserve numbers were listed on the margin of the map and were struck off as assigned in the field.

While materials were being assembled a complete field survey was made with the assistance of the Kentucky and Tennessee State Health Departments. The health department representatives were principally responsible for obtaining the necessary permits from the owners of the dwellings and establishing personal relations between the people of the area and the Tennessee Valley Authority construction group. This was an important contribution because much time is consumed in explaining the program and in answering questions as to why and where the mosquito-proofing was required. As each house was visited a number corresponding to the map location was stenciled on the house and detailed information obtained as to door dimensions with hanging strips indicated left or right, estimate of floor and ceiling paper, dimensions of fireplace opening, and any other pertinent information that would assist the construction forces in doing the mosquito-proofing. A survey party was usually composed of three persons; one Tennessee Valley Authority Health and Safety Department representative, one Construction and Maintenance Division carpenter, and a State Health Department representative. Three such parties working from Murray, Kentucky; Paris, and Waverly, Tennessee, accomplished the survey of 1113 houses in 52 party days. Field work was suspended on Saturday since people in rural areas are usually away from home on that day. Approximately 22 houses were surveyed per party day. A total of 9865 miles of car travel was required to cover the nine counties bordering the proposed summer impoundage.

Field Survey Data

The information collected on the field survey was tabulated for the preparation of the construction of work sheets. These work sheets presented in numerical order a list of the houses to be mosquito-proofed by number, map, and occupants name with the required number of right and left hung doors of proper dimensions for each house. A short remark column was included to report any unusual conditions at the houses, such as: "Require 200 sq. ft. of wall and ceiling paper," or "Check openings around attic door," or "Screen

section of front porch," etc. The work sheet was reproduced in ditto in quantities to provide several copies for the prefabrication shop, office, and field units. The field foreman working closely with the shop could order doors for certain groups of houses by referring to work sheets. Every house practical for mosquito-proofing, whether occupied or not, was listed so that none could be missed during the actual construction. These work sheet ledgers served excellently as a permanent record of the mosquito-proofing work.

From the door size summary, lists were prepared giving the total number of right and left door combinations required, to facilitate the shop work and permit stocking of standard door sizes. Of 3664 doors analyzed, there were 94 different size combinations of which 75 combinations occurred in numbers less than 1% of the total doors and required special shop orders. The remaining 19 common door sizes were assembled and stocked in the percentage of total doors as shown in table 1.

TABLE 1

Tabulation of Common Door Sizes Indicated Left or Right Hung in Per Cent of Total Doors Required (Based on 3664 Doors)

Dimension	% of Total Doors			Dimension	% of Total Doors		
Inches	Left	Right	Total	Inches	Left	Right	Total
32 x 80	9.0	10.0	19.0	36 x 84	1.5	1.5	3.0
34 x 82	5.5	6.0	11.5	32 x 72	1.0	1.0	2.0
34 x 80	6.0	5.5	11.5	34 x 76	1.0	1.0	2.0
32 x 78	4.0	4.0	8.0	34 x 72	1.0	1.0	2.0
34 x 78	2.0	2.0	4.0	36 x 80	1.0	1.0	2.0
32 x 82	1.5	2.0	3.5	36 x 78	0.5	1.0	1.5
32 x 76	2.0	1.5	3.5	36 x 74	0.5	1.0	1.5
36 x 82	1.5	1.5	3.0	34 x 84	0.5	1.0	1.5
32 x 74	2.0	1.0	3.0	36 x 72	0.5	0.5	1.0
34 x 74	1.5	1.5	3.0				

The requirements for screen wire of various widths based on the sample and complete surveys are given in table 2.

Table 3 gives the number and percentage of screen doors of given lengths and widths found at the 1113 houses surveyed.

Prefabrication Shop for Screen Doors

In the Tennessee Valley Authority's past mosquito-proofing operations a standard screen door was employed, sturdily constructed of full 1" x 3" cypress having sheet metal corner reinforcing plates. The screen wire in the bottom panel was reinforced with galvanized hardware cloth. It was evident from early forecast of available lumber that the standard door design would have to be altered. The Construction and Maintenance Division planned to use shop facilities for manufacturing the doors; thereby, permitting construction

TABLE 2
Analysis of Screen Wire Requirements from Sample Survey

Width Inches	Sq. Ft.	Lin. Ft.	% of Lin. Ft.	Screen Wire Purchased Sq. Ft.	Lin. Ft.
20	58	35	0.1	0	0
22	217	118	0.1	0	0
24	11,908	5,954	7.0	11,800	5,900
26	23,484	10,870	12.8	25,567	11,800
28	47,082	20,194	23.8	42,233	18,100
30	57,430	22,972	27.0	60,750	24,300
32	29,229	10,951	12.8	36,267	13,600
34	8,397	2,946	3.4	15,017	5,300
36	24,382	8,127	9.5	23,400	7,800
38	4,073	1,289	1.4	3,483	1,100
40	4,284	1,287	1.5	4,000	1,200
46	25	6	0.1	0	0
48	2,540	635	0.7	2,000	500
Total	213,109	85,384	100.0	224,517	89,600

details usually not possible for hand construction. On Figure 1 is illustrated the new door design requiring standard mill size lumber which was readily available. All members except the bottom rail were cut from standard 25/32" x 3-5/8" net grade C southern pine. The bottom rail was cut from 25/32" x 7-5/8" material, the added width serving to protect the lower screen panel where hardware cloth was formerly used. Instead of the standard miter joint with metal gusset plates the new design corner joint is a half-lapped, clinch-nailed, and glued with casein. The intermediate joints are of the butt type reinforced with 2-3/8" hardwood dowels glued in place. In studying Figure 1 it will be noticed that both the pull rail and hinged rail have identical milling for all members except the top half-lap which is finished to lengths as required. The diagonal brace with its cross rail has standard milling, except for variations in width, and is reversible to make either right or left hung doors. Thus, every door, regardless of its dimensions or hanging position, has common milling except for the required lengths or widths. This feature permitted the mass production of members which could be made up into right or left hung doors of various dimensions. The shop foreman utilizing information in table 3 could select, cut, and mill in continuous lots members of required lengths and widths. These members were stored in labelled bins for assembly into proper combinations.

In the past some failure had been experienced in screen wire tacks pulling loose from the doors and window facings. The present plan called for the use of 1/4" x 3/4" wood screen moulding to hold the wire more securely.

TABLE 3

Number of Screen Doors of Given Lengths and Widths Found at 1113 Houses Surveyed

DOOR LENGTHS IN INCHES	DOOR WIDTHS IN INCHES													
	24	26	28	30	32	34	36	38	40	42	44	50	Total	%
46										1			1	
50								1					1	
60		2			1	1							4	0.1
62						1							1	
64				1		1							2	
66				3	4	4	3	1					15	0.4
68		1	1	5	13	8	5	3			1		37	1.0
70		1		8	23	14	6	2					54	1.5
72		4	14	20	81	71	37	15		1	1		244	6.7
74	1	9	11	21	111	98	49	22	8	1			331	9.0
76		3	9	17	124	76	20	12	7				268	7.3
78	4	2	2	20	310	157	50	18	3	1			567	15.5
80	1		6	25	686	405	62	26	3				1214	33.1
82				7	126	417	113	15	2				680	18.5
84			1	1	12	48	97	28	2		1		190	5.2
86					3	5	11	31	2			1	53	1.5
88							1						1	
92								1					1	
Total	6	22	44	128	1494	1306	454	175	27	4	3	1	3664	
%	0.2	0.6	1.2	3.5	40.8	35.6	12.4	4.8	0.7	0.1				99.9

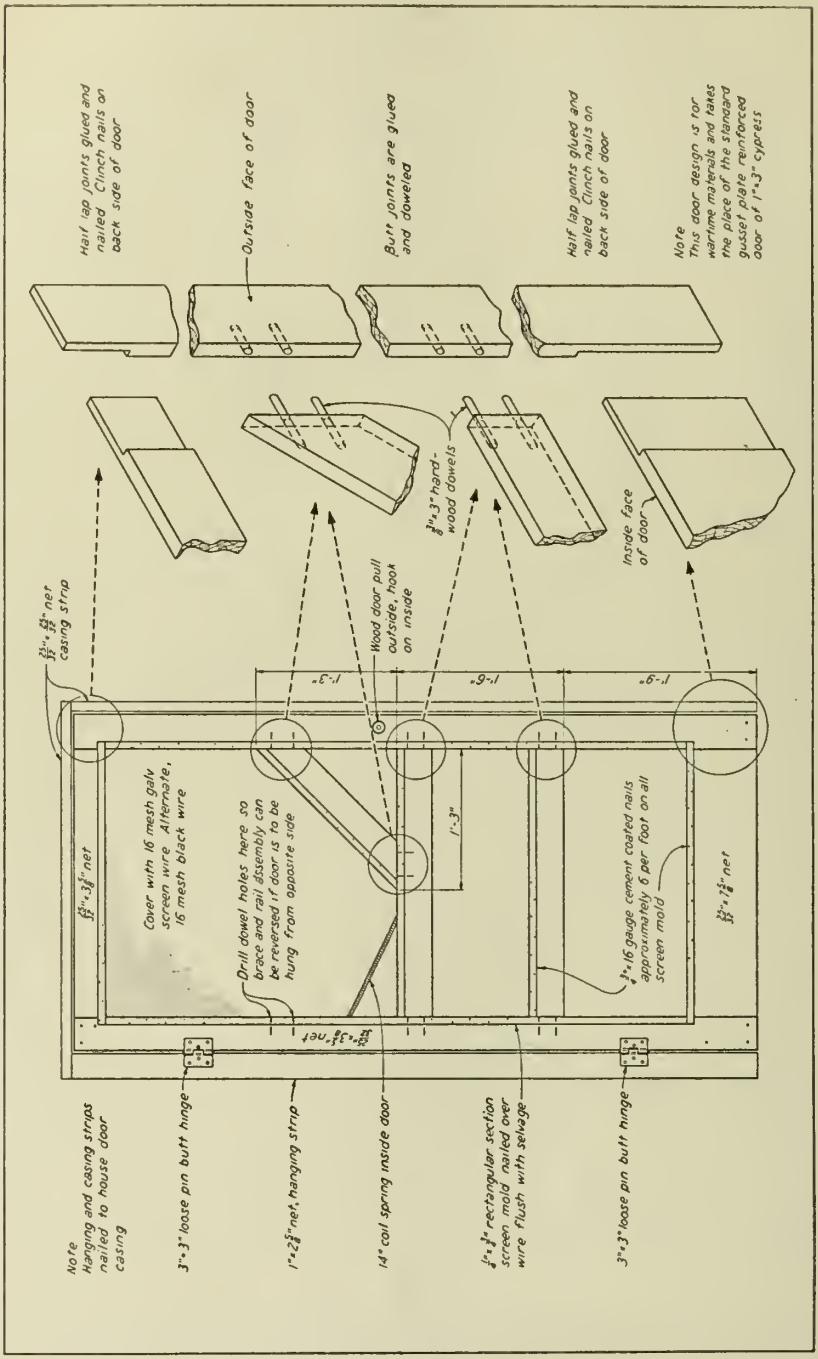

Fig. 1. *Screen door designed for mosquito-proofing program*

The mosquito-proofing warehouse and shop was located in Paris, Tennessee, and had floor space approximately 60′ x 100′. The mechanical equipment in the shop consisted of one 18″ diameter, circular saw mounted directly on the motor shaft. The entire unit is supported on a vertical column extending from floor level having adjustments for depth of cut and a radial movement for adjusting a horizontal track to accommodate any angle of cut. Cuts are made by manually pulling the saw and motor to the lumber by means of an overhead track. A removable butt block fixed to the guide strip conveniently gauged the desired length of stock. For making the lap joint, a similar circular saw was used mounted to make a horizontal cut. In lieu of a dado head three circular blades were mounted on the mandrel and positioned so that when the saw unit was moved across the face of the lumber one-half of the thickness of the material was removed, which prepared the member for the half-lap joint. The material was grouped in units and inserted under clamping devices in such way that when the saw was pulled forward and returned one end of three members was cut for half-lapping. Three cycles of this operation were required for each door. For drilling the dowel holes two electric hand drills were mounted horizontally side by side on a sturdy bench at proper hole spacing for the dowel butt joint. The drills being stationary it was necessary to provide jigs suitable for feeding the different members to the drills at the proper positions and angle. The stock for a door required nine operations on this drill rig. Separate benches were provided for the assembly of the frame and for applying the screen wire. The materials were selected from the bin in accordance with the daily work bills supplied by the shop foreman. The shop foreman, cooperating with the field units, was able to supply the assembly men with lists of the number and different size combinations of doors required by the day.

The first operation in the assembly of door frames was to dowel joint the diagonal brace to its intermediate member. Dowels were then placed into the vertical rails and the two intermediate members and diagonal brace positioned. Pressure was applied by two metal bar clamps which firmly seated the dowel butt joints. The top and bottom half-lap corner joints were next united. Until the completion of the clinch nailing of the corner joints the entire frame is held firmly in place by the bar clamps. Casein glue was applied adequately to all dowels and to the lap joints. The assembly bench was arranged with steel plates on either end to provide the rapid clinching of nails as driven.

The complete frame was next transferred to the screening bench where screen wire and moulding strips were attached. The bench was equipped with a rack at one end for supporting rolls of

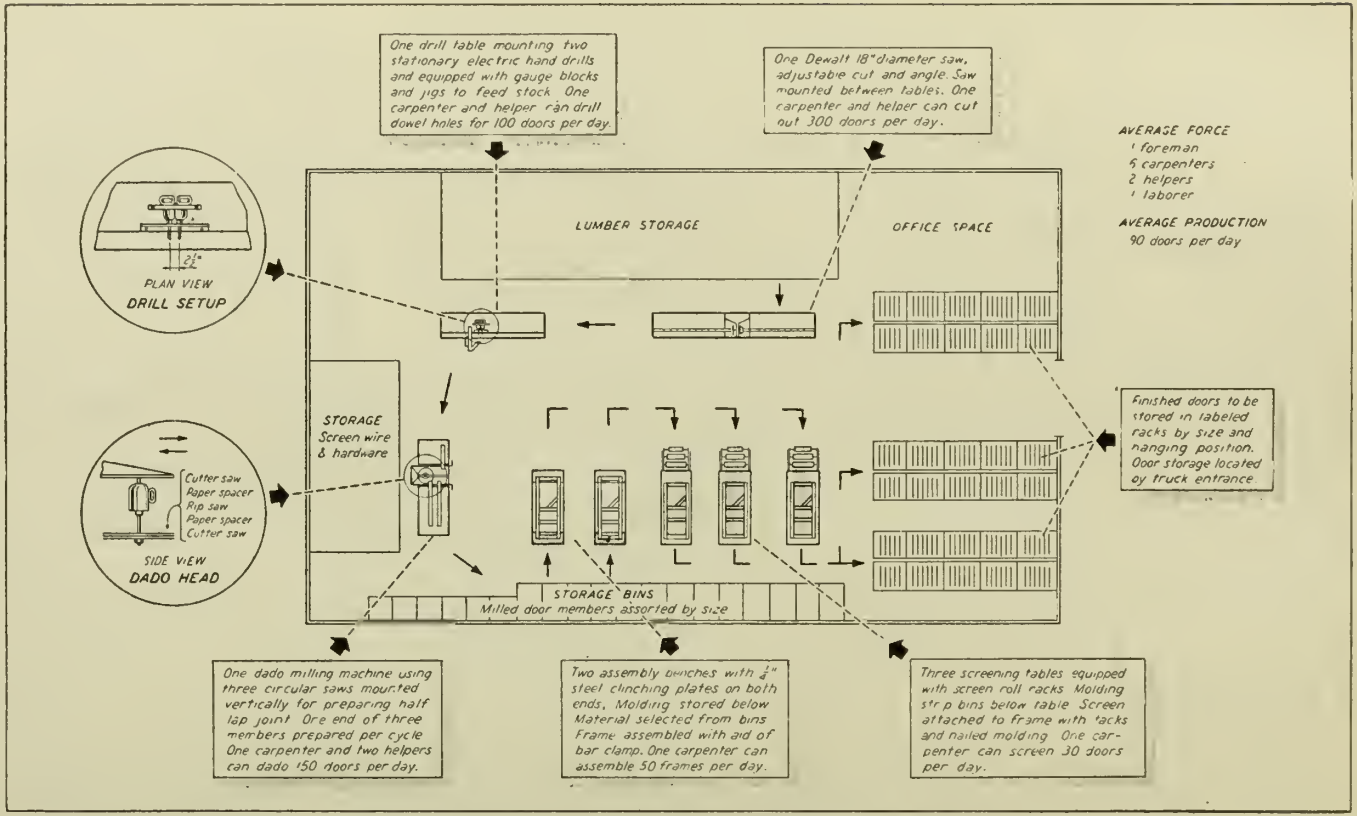

Fig. 2. Plan of screen door shop for mosquito-proofing program

various widths of wire which could readily be unrolled over the door frame. To prevent unnecessary waste of screen wire tacking was first completed at the end; the slack was drawn back and tacked before cutting the wire from the roll. Tacks were required sparingly to hold the screen in place until wood moulding strips were fixed. Approximately six 1" x 16 gauge cement coated nails per foot of mould were used to provide sufficient clamping of the wire. Hinges, springs, hooks, and pulls were not installed on the prefabricated door at the shop to facilitate storage and transportation. All completed doors were racked in bins according to size and hanging position.

On Figure 2 may be seen the plan layout of the door prefabrication shop with direction of flow of materials indicated. The capacity of the shop was 90 finished doors a day, with a force of one foreman, six carpenters, two helpers, and one janitor-laborer.

Field Procedure

From 8 to 10 carpenters, a foreman, a truck driver, and one 1-1/2 ton supply truck made up a field construction unit. A Health and Safety Department representative and the foreman surveyed the area a few days ahead of construction to become familiar with the road and house locations and to make decisions concerning vacant houses, porches, and extent of mosquito-proofing. A 1-1/2 ton stake body truck was outfitted with enclosed racks and seats for transportation of materials and crews. The truck driver distributed crews and materials as directed by the foreman's work sheet. Carpenters were assigned to the houses in groups of two to four, depending on the volume of work required. The truck remained in the area, supplying materials as needed and moving workers from completed houses to new locations. Before the house was recorded in the ledger as completed, a joint field inspection was made by the Tennessee Valley Authority and State Health Department representatives.

After a short period of training the carpenters became well versed in the methods of mosquito-proofing and their good workmanship was received favorably by the occupants of the area. There were, of course, some complaints and requests for additional work including painting, reroofing, etc. Generally, however, excellent working relationships were maintained through the assistance of the state and local health departments.

Construction Practice

The construction practice of the Kentucky Reservoir mosquito-proofing was the same as followed in the Wheeler Reservoir, (Kiker 1941). In addition to screening doors and windows, wall and ceiling paper, and floor coverings were used when necessary. All fire-

place openings were closed with removable screens of beaver board. Only 16 mesh galvanized screen wire was used. Full window screens were tacked sufficiently on to the facings, followed by screen moulding nailed at 2" spacings which held the wire securely. Furring strips were employed to provide a neat appearing and tight wire lap over the window sill. Fireplace hearths were usually very rough and past practice called for leveling holes with a cement grout to insure a tight fit for the screen. Satisfactory results were usually maintained until heat from the fire caused the grout to break up. In the Kentucky program a more permanent solution for mosquito-proofing the fireplace openings was obtained through "scribing-in" the contour of the rough hearth on the bottom member of the screen to obtain a mosquito-proof fit.

In some instances where rooms did not require complete overhead papering, the ceiling cracks were observed from the darkened attic and covered from above by tacking down paper between the joists. In this manner unsightly patch-work was removed from sight with effective mosquito-proofing results.

The general policy followed for the extent of mosquito-proofing of a house on the emergency program is outlined as follows:

1. Houses occupied at time of construction, or likely to be occupied soon afterwards.
2. Parts of houses, depending upon type and repair condition, received consideration for mosquito-proofing in the following order of importance.
   a. Bedrooms only
   b. Bedrooms and kitchens
   c. All rooms except the hallway
   d. All the house
   e. All of the house and porch

The screening of porches received careful consideration. Poor flooring, unstripped boxing, and ceiling openings made most porches impractical for mosquito-proofing. The reason for not screening porches was made clear to the owner and often repairs were made by the tenants in time to have the porch included.

Of the total houses numbered and surveyed initially, several were unoccupied, torn down, burned down, or otherwise eliminated from mosquito-proofing. Concurrently several new houses had been built or moved into the area requiring mosquito-proofing. At the termination of the program in June 1944, 1032 rural houses had been satisfactorily mosquito-proofed. The Construction and Maintenance Division indicated that an average of 35 man hours of labor was required to apply the mosquito-proofing. The operation was decentralized as much as possible over the nine counties in Kentucky and Tennessee with sub-bases located at Murray, Kentucky;

and Camden, Tennessee. A total of 40,000 miles of travel and 5718 truck driver hours were required to distribute men and materials. Below is tabulated the summary of materials used for the average house in the Kentucky Reservoir area.

SUMMARY OF MATERIAL FOR AVERAGE HOUSE MOSQUITO-PROOFED
(*Based on* 1113 *Houses*)

Average House:

Number of doors—3.3
% hung from right—50.5
% hung from left—49.5
Number of windows—7.0
Number of fireplaces—0.65

Screen Wire Requirements Per House

No. 16 mesh galvanized wire cloth	*Lin. Ft.*	*Sq. Ft.*
Average for doors	19.7	48.5
Average for windows & porches	57.0	143.0
Screen wire total	76.7	191.5

Standard Beaver Board for Fireplace
Average material per opening ..... 15.3 Sq. Ft.

Wall and Ceiling Paper (90 *lb. Basis Kraft*)
Average material per house ..... 272 Sq. Ft.

Floor Paper (45 *lb. Smooth, Prepared Roofing*)
Average material per house ..... 156 Sq. Ft.

Wood Screen Mould ¼" x ¾"
Average for doors and windows ..... 160 Lin. Ft.
Average for paper and miscellaneous ..... 180 Lin. Ft.
Total moulding per house ..... 340 Lin. Ft.

Sheet Metal for Small Openings (30 *gauge*)
Average per house ..... 3 Sq. Ft.

Summary

The delay in the closure of the Kentucky Dam prevented the impounding of the lake during the winter of 1943 and resulted in a schedule of partial impoundage for power production to elevation 350′ in the late summer of 1944. The malaria control program was altered to meet the emergency by mosquito-proofing dwellings within one mile of the 350′ contour.

Material requirements were determined and ordered in a minimum length of time by the random sample survey of houses over the area. The estimates of materials provided by the sample survey proved to be adequate for the program.

One complete house to house survey served for mapping and numbering houses, determining door requirements and obtaining other necessary information. Survey information was tabulated into field work sheet ledgers which were utilized for several purposes, including shop prefabrication, field construction, and office records. Tables and charts analyzing survey data were prepared which may be of value in estimating future mosquito-proofing.

An efficient shop was set up by the Construction and Maintenance Division for the prefabrication of the modified screen door.

Field methods and procedures were similar to past mosquito-proofing practice and excellent public relations were maintained through the cooperation of the state and local health departments.

A total of 1032 houses were mosquito-proofed in nine counties bordering the Kentucky Reservoir in less than six months time at a reasonable cost for current prices of materials and rates of labor.

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EDUCATIONAL ACTIVITIES AS RELATED TO THE RETURNING MALARIA CARRIER PROBLEM*

WILLIAM S. BOYD
United States Public Health Service, M.C.W.A., Atlanta

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Malaria Control in War Areas was inaugurated in March 1942 as an emergency program to protect war personnel from malaria. While industrial establishments have been included, the program has been primarily concerned with the protection of military personnel. Within the reservations, mosquito control work and malaria discipline have been the responsibility of the Army and Navy.

The major educational responsibility under the MCWA program has been in orienting and extending the training of operational personnel. To meet this responsibility a two weeks' course, consisting of classroom, laboratory and field work, was set up in the Headquarters Office. To increase the effectiveness of classroom and laboratory training, extensive use has been made of visual aids. The lack of available aids of the type adaptable to the field of malaria control necessitated the development of facilities for the production of motion pictures, film strips, lantern slides, photographs and other graphic materials. To furnish field personnel with information concerning developments in the program, reports and field bulletins have been issued periodically. In addition to the preparation of pictorial keys, charts and field handbooks, an attempt has been made to procure all available informational aids considered suitable for field training and distribution facilities for these materials have been established. Additional informational services have been rendered by answering inquiries, consultations, and supplying source materials and source references in response to many requests from within the organization and from both lay and professional groups and individuals outside of the organization.

In an attempt to reduce the malaria hazard in areas beyond the one-mile operational zone a limited community education program was developed through the Central Office of the U. S. Public Health Service. In this program teachers were utilized during the summer months. After a short period of training they returned to their respective localities to carry on educational work under the direction of the county health officer. This program was developed as a line of secondary defense.

Malaria Control in War Areas now contemplates a shift in the direction of its protective efforts. To offset the danger of re-

*This paper was presented at the annual meetings of the National Malaria Society in St. Louis, Missouri, 14 November 1944.

turning malaria carriers to the civilian population it is proposed that the program extend control measures to areas of higher endemicity beyond the one-mile operational zone, provide surveillance in questionable regions and set up mobile units for the control of malaria outbreaks in non-endemic areas.

Under this program it will be necessary to increase and accelerate training activities. Not only will new personnel require instruction but it will be necessary to interpret the extended control activities to present operational personnel and train them in new phases of their work. Major dependence will be placed on residual DDT house spraying where the population is scattered. Field personnel will require training in the technique of applying this insecticide, with emphasis on the precautionary measures to be observed in order to increase effectiveness and afford a wide margin of safety in its use.

In the conversion of control activities from military personnel to the civilian population, lay education must move up from the area of secondary defense to the line of primary attack. In the program of malaria prevention the aims of the educational activities are identical with those of operational activities and the two must be closely integrated. To disregard this fact may mean the ultimate failure of both phases of the program.

Through the positive approach of education we must build into our control procedures an element of permanence to insure their long range benefits and maximum coverage. While certain phases of the educational activities are now in progress and others planned in detail, only the general aspects of the program will be included in this discussion.

While education involves the patient stimulation of people to recognize and meet their responsibility, it is also capable of producing immediate and tangible results. The first result to be derived from the educational efforts is an understanding on the part of communities and individuals of the immediate problem and the meaning of the malaria control procedures in terms of their own welfare. The next step is participation which will facilitate and increase the effectiveness of the immediate operational program. The program proposes larvicidal control and incidental drainage in approved communities. If these communities are stimulated to contribute material and other assistance they will not only benefit from the permanent drainage which is installed but the malaria control efforts will become a matter of community interest and pride. It will be something that is done by the community instead of something that is done for the community by outsiders. Under

such conditions the community is far more likely to feel the necessity for the maintenance of gains already made and assume a responsibility for their own protection from malaria and other mosquito-borne diseases.

The immediate effect of education on the individual will in a sense follow that on the community as a whole. It will increase his understanding of the problem and add significance in terms of his own welfare to the operations which are being carried on. He can add to the effectiveness of the control procedures used by mosquito-proofing his house, reducing mosquito breeding on his own premises and employing other individual protective measures. No matter how extensive our preventive measures are there are certain things that must be done by the individual if complete prevention is attained. These the individual can begin doing immediately. People learn by doing. They will never learn to prevent malaria until they are given an opportunity to participate in malaria preventive activities. Therefore, one of the cardinal principles in this educational program is the attainment of individual and group participation in the malaria preventive procedures.

Providing the techniques and leadership in developing community education programs is a function performed best by specialized personnel. But, the program in its entirety must be participated in by all those who are concerned with the problem. Opportunities will be afforded lay leadership to study the problem and take the initiative in developing individual and collective action programs. An effort will be made to inject and integrate malaria educational emphasis into every possible channel of lay education.

The major stream of our educational efforts will be directed toward those in greatest danger of contracting malaria from the returning carriers of this disease. However, a portion of this stream must be diverted into channels which will reach individuals whose activities are related to the malaria problem. This will involve reaching lay and professional groups at all levels. The present educational program includes plans for reaching practicing professional groups whose activities are directly or indirectly related to the malaria problem, and individuals now receiving training who may later engage in such activities.

Plans will be developed with those concerned with the construction of highways and various types of impoundments so that malaria preventive measures will be incorporated in the cost of construction and maintenance.

Special work with medical societies will be undertaken with the hope of stimulating improvements in the technique of malaria diagnosis and better case reporting. Initial steps have been taken in stimulating an increase in the teaching of the principles and practices of malaria prevention in general engineering schools as well as in sanitary engineering courses.

Educational activities with colleges, graduate and medical schools will be aimed at increasing attention to the parasitological, entomological, and other biological phases of malaria, with particular emphasis on the practical aspects of the problem.

The gratifying eventual results of past, present and future cooperative efforts will be manifested when men managing various enterprises cease to create malaria hazards, and when individuals develop a sense of responsibility for protecting themselves from malaria and for providing, with local funds, measures which keep the community free from the disease.

BOOK REVIEWS

(Continued from page 132)

case of *aegypti,* for instance, although this species is still often referred to as *calopus* or *argenteus,* no mention is made of these names. Some confusion may be caused by a note given under *C. quinquefasciatus* which states, "It would seem advisable to adopt the name *fatigans* (for this species) since it is used in all other literature and has been accepted by Edwards (1932)." It might have been better had the author used the name *fatigans* and then made a formal appeal for adoption of the name to the International Commission of the Zoological Nomenclature if he really believes the name should be changed.

The bibliography in this new edition has been expanded considerably to include sources of information and these are classified by content so that the user can readily obtain further specific information on any subject without a general literature search.

The format is attractive and the book is nicely illustrated by well chosen text figures and by large series of excellent drawings showing details of adult and larval structures. Doctor Matheson is to be commended for preparing this timely revision of his Handbook.

G. H. Bradley.

Practical Malaria Control. Carl E. M. Gunther. Cloth. Price, $2.50. Pp. 91 with a brief foreword by Professor Harvey Sutton of the School of Tropical Medicine and Hygiene, University of Sydney. New York: The Philosophical Library, 15 East 40th Street. 1944.

This little monograph, designed as a practical handbook for field workers, is based largely upon the author's observations on malaria in the Mandated Territory of New Guinea over a period of ten years. The book is well written and rather gives one the impression of a person speaking rapidly and interestingly from a background of practical experience. The manuscript was probably prepared not later than 1940 for the publishers state that the author is a prisoner of war, presumably since the campaign in Malaya where he was a medical officer with the Australian forces.

As the author notes in a foreword, the book does not pretend to be a broad treatise on malariology, and because of its brevity the narrative trends to be dogmatic. When dogmatic generalizations represent the concensus of current thinking they cannot be criticized stringently, but generalizations in malariology are always a bit dangerous and many in this book would probably be modified by the author in the light of knowledge gained in the past five years.

The book is divided into four parts: Antimalarial Measures (39 pages); Diagnosis (19 pages); Treatment (22 pages); and Complications of Malaria (9 pages). From the standpoint of general usefulness, the first section is probably of most value, particularly the material on entomological matters pertaining to malaria control. Some of the opinions expressed in the three predominantly clinical parts of the book are more likely to be challenged. For instance, the author apparently places considerable reliance on the diagnostic value of the total leucocyte count, which he states categorically "is normal in malaria;" and again, that "a rise beyond 10,000 (per cmm.) could not be due to malaria." Quinine is evidently favored by the author over atabrine for both suppressive and clinical treatment.

The reviewer's chief criticism of the clinical sections is that no where in them is there adequate differentiation between *falciparum* and *vivax* infections, although such differentiation can usually be made inferentially by the critical reader. As an example, in a discussion of total parasite counts and their value in prognosis, the comments are not of much value except in terms of species parasitism, and these are not given.

In reading the last three parts of the book, the reader has to keep constantly in mind that the author is writing from an experience based on individuals living in a highly endemic situation who have been taking quinine as a suppressive for long periods of time; and who are probably all infected, sometimes with more than one species of *Plasmodium*. The book probably would have considerable practical usefulness for a person without much field experience in malariology faced with situations similar to those upon which the author's experience was based. The price seems excessive.

—Robert Briggs Watson.

The Mosquitoes of New Jersey and Their Control. Thomas J. Headlee. Cloth. Price, $4.00. Pp. 326 with 77 illustrations. New Brunswick, N. J.: Rutgers University Press. 1 May 1945.

For nearly half a century the work of the New Jersey Agricultural Experiment Station, the New Jersey Mosquito Extermination Association, and related agencies has served as a model for mosquito control workers, particularly those concerned with salt marsh and other pest mosquito problems. For much of this time, Doctor Headlee has given inspiring leadership to the work in New Jersey. It seems particularly fitting that he should bring up to date the experience of three years of work.

More than half of the book (198 pages) is a chapter given to discussion of the biology of thirty-seven of forty-one mosquito species that have been found in New Jersey. This section gives for each species a general characterization and descriptions of the adult and larval forms and habits. In the case of important species, such as *Aedes sollicitans*, this material is given in considerable detail. This chapter is supplemented by one in which keys for adult female and larval forms of these species are given; also given are most useful eye and hand-lens keys to adults of fifteeen and to larvae of twelve common species. Another supplementary chapter discusses the relationships of temperature, water, food supply, natural enemies of mosquitoes (particularly fish) to the natural history of mosquitoes; and the attraction of mosquitoes to man. Still another gives the prevalence of mosquitoes in New Jersey based on light trap collections over a ten-year period. From these data it is interesting to note that *Anopheles quadrimaculatus* is the seventh most prevalent species, particularly since this mosquito is not attracted to light to the same extent as *A. cruciens* and *A. walkeri*, the fourth and sixth, respectively, most prevalent species.

Additional chapters are given on the history of mosquito control in New Jersey; on the principles and detailed procedure of mosquito control operations; on the use of larvicides; on mosquito repellents; on laws relating to mosquito control; and finally, on the economic effect of mosquito reduction.

The book is well written. Fundamentally scientific, the subject matter is presented in such a way as to make it understandable and interesting to students, practical mosquito workers, and laymen. The book is well and attractively bound and well printed.

—Robert Briggs Watson.

Malaria: Its Diagnosis, Treatment and Prophylaxis. William Newbold Bispham, M. D., Col. U. S. Army, Retired. Cloth. Price, $3.50. Pp. 183 with 5 plates, 4 in color. Baltimore: Williams and Wilkins, 1944.

The publishers claim that this book is "designed to fill a great and urgent need for a distinctly clinical treatise providing sound, authoritative and up-to-date information on all clinical aspects of the malarial problem." Granting for the sake of argument that such a need exists, the reviewer submits that this book does not fill it. That the book is not a "distinctly clinical treatise" is indicated by the fact that less than half of the text can be classified as material likely to be of interest to the average clinician.

The book as a whole is poorly written from the standpoints of composition and scientific accuracy. There is frequent repetition. References cited often are not selected critically and are sometimes archaic, resulting in the inclusion of material of doubtful accuracy or importance. The relative emphasis which has been placed on certain subjects, and statements which do not agree with modern concensus, or are inaccurate, lead to the conclusion that the author did not have a profound grasp of his subject. For instance, a page each is given to discussion of the so-called cultivation of malaria parasites and to the Henri reaction, but less than 3 pages to therapeutic malaria. Complement fixation in malaria, which recently has excited some interest, is discussed in a short paragraph.

Some 20 pages are given to discussion of the natural history and differential morphology of malarial parasites. Much of this material is redundant and the narrative is confusing. The fate of sporozoites, about which so much important work has been done in recent years, is dismissed with the statement (page 24) that "The infection is commenced by the entry of a sporozoite into a red corpuscle, a process which has been seldom observed." There is no comprehensive discussion of nonerythrocytic forms. On page 94, "gametes" and "gametocytes" are confused.

As an example of an inaccurate statement of practical clinical importance, atabrine musonate is recommended (page 123) for parenteral therapy. This compound has never been used widely in this country. No mention is made of atabrine dihydrochloride, the compound in common use; however, since it is probably the only one obtainable the error is not of much consequence.

The book is unusual, perhaps unique in one respect; most of the chapters were reviewed and presumably approved prior to publication by an individual with special interest in the subject reviewed by him. Most of these gentlemen are well known to the reviewer, and it is difficult for him to believe that they have given their unqualified approval to the chapters associated with their names.

The concluding chapter is a contributed article on the "Prevention and Treatment of Malaria in West Africa" by Dr. Lowell T. Coggeshall. While this article is an excellent brief treatment of the subject, it seems out of place in this book.

—Robert Briggs Watson.

Manual of Clinical Mycology. Prepared under the Auspices of the Division of Medical Sciences of the National Research Council by Norman F. Conant, Phd., Donald S. Martin, M. D., David T. Smith, M. D., Roger D. Baker, M. D., and Jasper L. Calloway, M. D. Price, $3.50. Pp. 348 with 148 illustrations. Philadelphia and London: W. B. Saunders Company. 1944.

One would imagine that with all the books available to the medical sciences that no loophole existed for an author to fill a gap in our formal written knowledge. That it can be done is well demonstrated by this little volume, the product of the combined efforts of a group of research workers at the Duke University School of Medicine who, during the past ten years, have conducted a broad systematic investigation of human mycotic disease.

Since the author group is composed of an immunologist, mycologist, clinician, pathologist, and dermatologist, one would expect to find (and does) these various fields well represented in the text. Thus this manual should be of considerable use to the broad group of readers usually referred to in reviews of medical books.

A good example of this general utility is found in the unusual chapter on contaminants which should not only be of help to the laboratory worker but will also aid the clinician in evaluating the significance of laboratory reports.

The many illustrations are well chosen and reproduced, while the entire volume gains considerably from its compact, readily legible format.

Harry A. Feldman.

Manual of Tropical Medicine. Prepared under the Auspices of the Division of Medical Sciences of the National Research Council by Thomas T. Mackie, Col., M. C., A. U. S.; George W. Hunter, III, Maj. Sn. C., A. U. S.; and C. Brooke Worth, Capt. M. C., A. U. S. Price, $6.00. Pp. 727 with 287 illustrations, 6 in color. Philadelphia and London: W. B. Saunders Company. 1944.

This, the latest of the military medical manuals sponsored by the National Research Council, is the most ambitious to date. It is also a most useful and practical text, reflecting the large experience of the authors and their collaborators in the instruction of medical officers at the Army Medical School. The authors have taken full advantage of the rapid and recent advances in the field of tropical medicine which fighting a global war has brought and have brought this material together in a concise and usable form.

The material covered includes not only infectious diseases but also a section on nutritional diseases, a very complete and useful section on medically important arthropods and their control, and a valuable section on laboratory and diagnostic methods. The completeness of the manual is attested to, for example, by discussions of cutaneous diphtheria, medically important animals, and effects of heat.

The book is well organized and is throughout thoroughly readable and usable. Many excellent photographs, tables, drawings, maps, and a complete index enhance the value of this manual which should serve as a valuable aid to medical officer, practitioner, and public health officer alike.

Franklin D. Murphy.